NOVARIS

SURGE PROTECTION MASTERCLASS

From Standards to Real-world practice.

INSTITUTE OF INTEGRATED ELECTRICAL ENGINEERS OF THE PHILIPPINES - SINGAPORE CHAPTER

17 May 2026

The Surge Protection Specialists

Over 30 years of Experience in Surge Protection

Speaker – Mr. Phillip Tompson

Phillip Tompson is the Founder and Managing Director of Novaris Pty Ltd. Novaris was established in 1993.

His Professional Profile

- Fellow, Institution of Engineers Australia
- Charted Professional Engineer
- Life Member of IEEE
- 30 years experience in lightning and surge protection design

Nominated representative in Australian Standard Committee EL-024 responsible for preparation of AS/NZ1768

Represents Australia on IEC Standards Committee TC81 & SC37A related to lightning and surge protection

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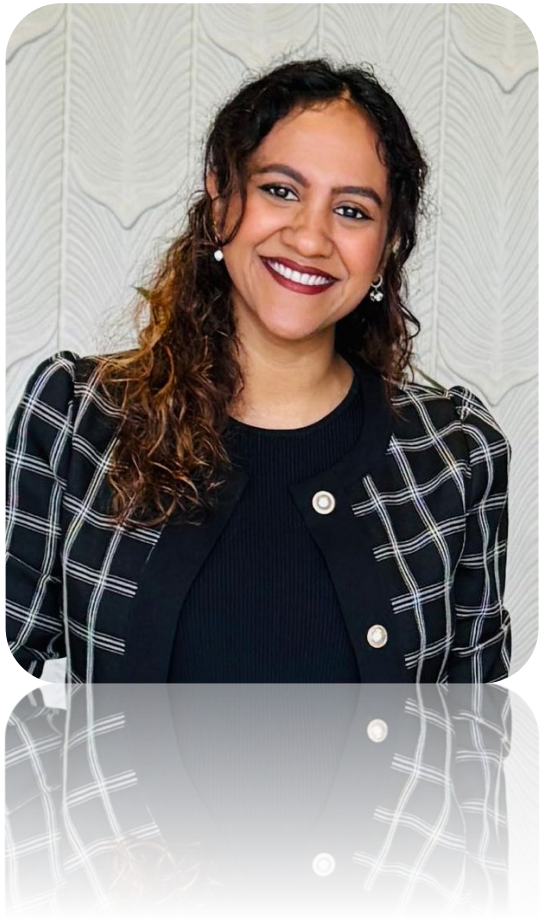
Speaker – Ms. Josephine Winnie



Josephine is the Solutions Architect of Novaris, Singapore.

Her Professional Profile

- Masters Degree in Electrical Engineering specialized in Automation & Control from NUS, Singapore
- Worked as DCS Lead Engineer with Yokogawa
- Specializes in Surge protection solutions for Process control & Industrial Automation

Based in Singapore, she develops practical surge protection solutions in line with standards, and delivers coordinated protection strategies that address operational reliability, system availability, and real-world business risks across the SEA region.

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LIGHTNING STRIKES

Lightning Strikes

Photos Courtesy: Simon Lim

Lightning Strikes

Photo Courtesy: Renee Doyle

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Lightning Eliminators – Dissipation Arrays

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ESE Terminals – Early Streamer Emission

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Self Protected Structure – all metal

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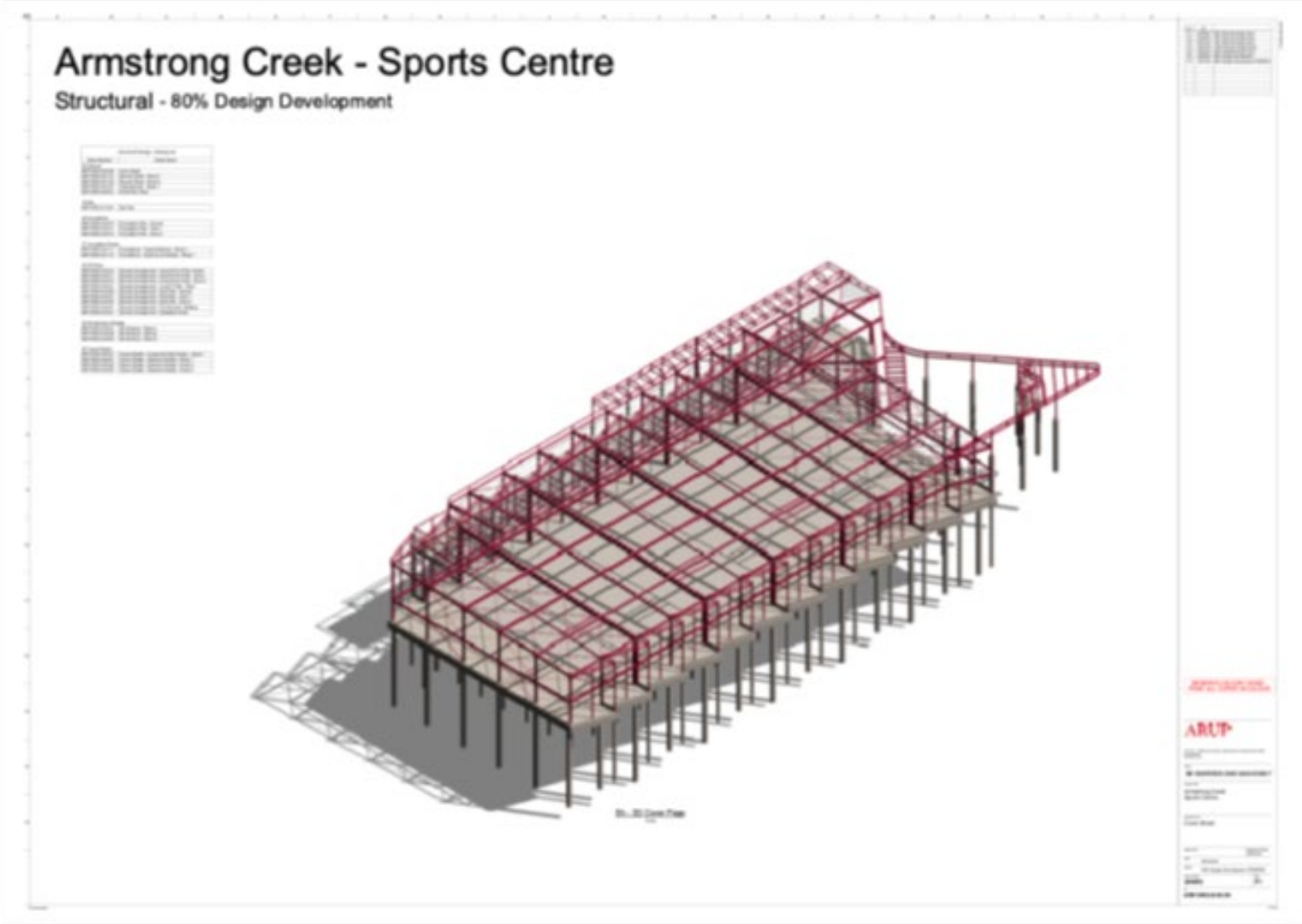
Self Protected Structure



Don’t try this

IEC 62305 AND IEC 61643 STANDARDS

IEC Standards

- **IEC 62305** **Lightning Protection**
- IEC 62305-1 General principles
- IEC 62305-2 Risk management
- IEC 62305-3 Physical damage to structures and life hazard
- IEC 62305-4 Electrical and electronic systems within structures

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IEC Standards – IEC 61643: Low-voltage Surge Protection Devices

▪ **IEC 61643-01**	Surge protective devices connected to low-voltage power distribution Systems – General Requirements and test methods
▪ **IEC 61643-06**	Low-voltage surge protective devices - Requirements and test methods on **SPD specific disconnectors** (**in draft**)
▪ **IEC 61643-11**	Surge protective devices connected to low-voltage power distribution systems – Requirements and tests
▪ **IEC 61643-12**	Surge protective devices connected to low-voltage power distribution systems – Selection and application principles
▪ IEC 61643-21	Surge protective devices connected to low-voltage telecommunications and signaling networks – Performance requirements and testing methods
▪ IEC 61643-22	Surge protective devices connected to low-voltage telecommunications and signaling networks – Selection and application principles

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IEC Standards – IEC 61643: Low-voltage Surge Protection Devices

- IEC 61643-31 — Surge protective devices for specific application including DC - Requirements and tests for SPDs in photovoltaic applications – Requirements and tests
- IEC 61643-32 — Low-voltage surge protective devices – Surge protective devices for specific use including DC- Selection and application principles for SPDs connected to photovoltaic installations
- IEC 61643-41 — Surge protective devices connected to low-voltage DC power systems - Requirements and test methods
- IEC 61643-42 — Surge protective devices connected to low-voltage DC power systems - Selection and application principles.

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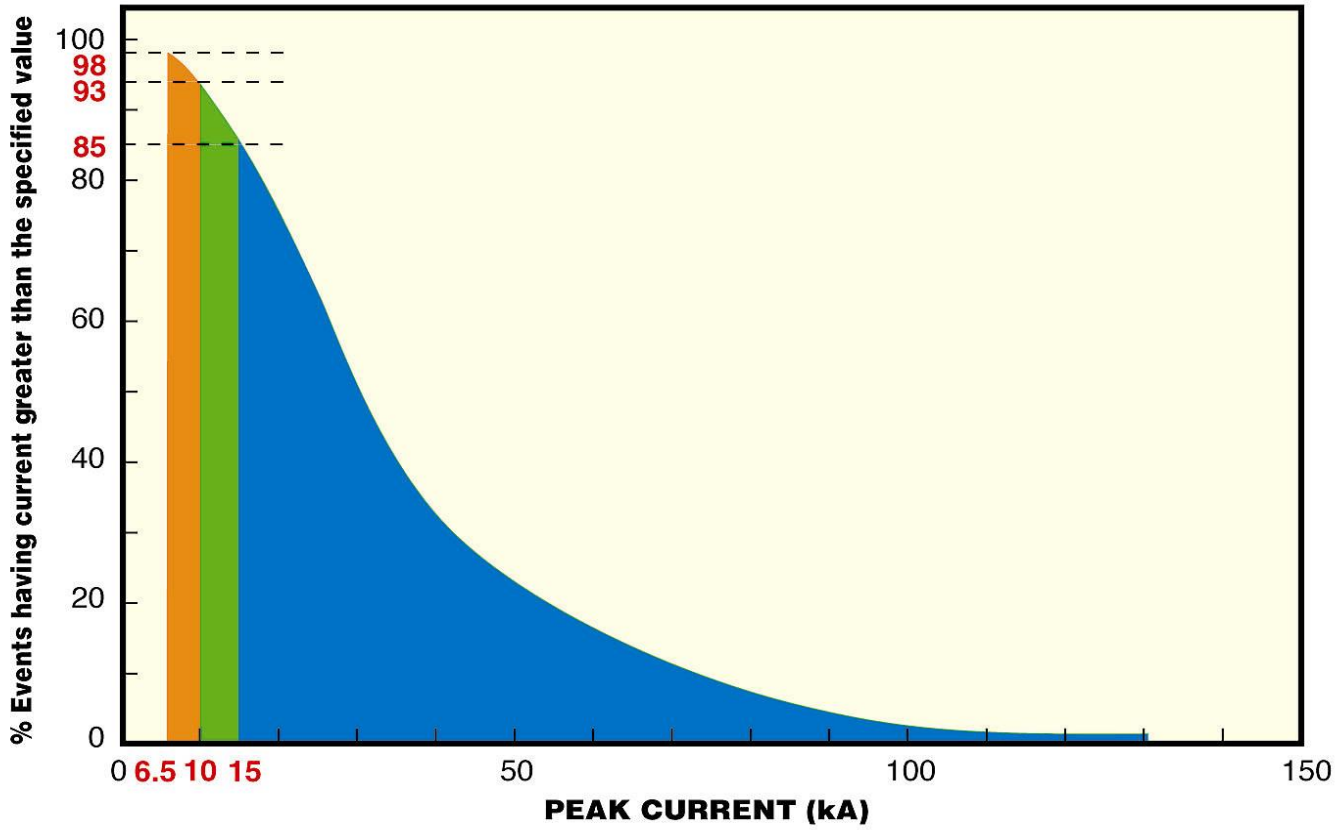
Peak Current Distribution

- Lightning properties follow ‘log normal’ distributions
- The average peak current is 30kA
- Very large peak current
- IEC maximum 200kA

First stroke peak current distribution



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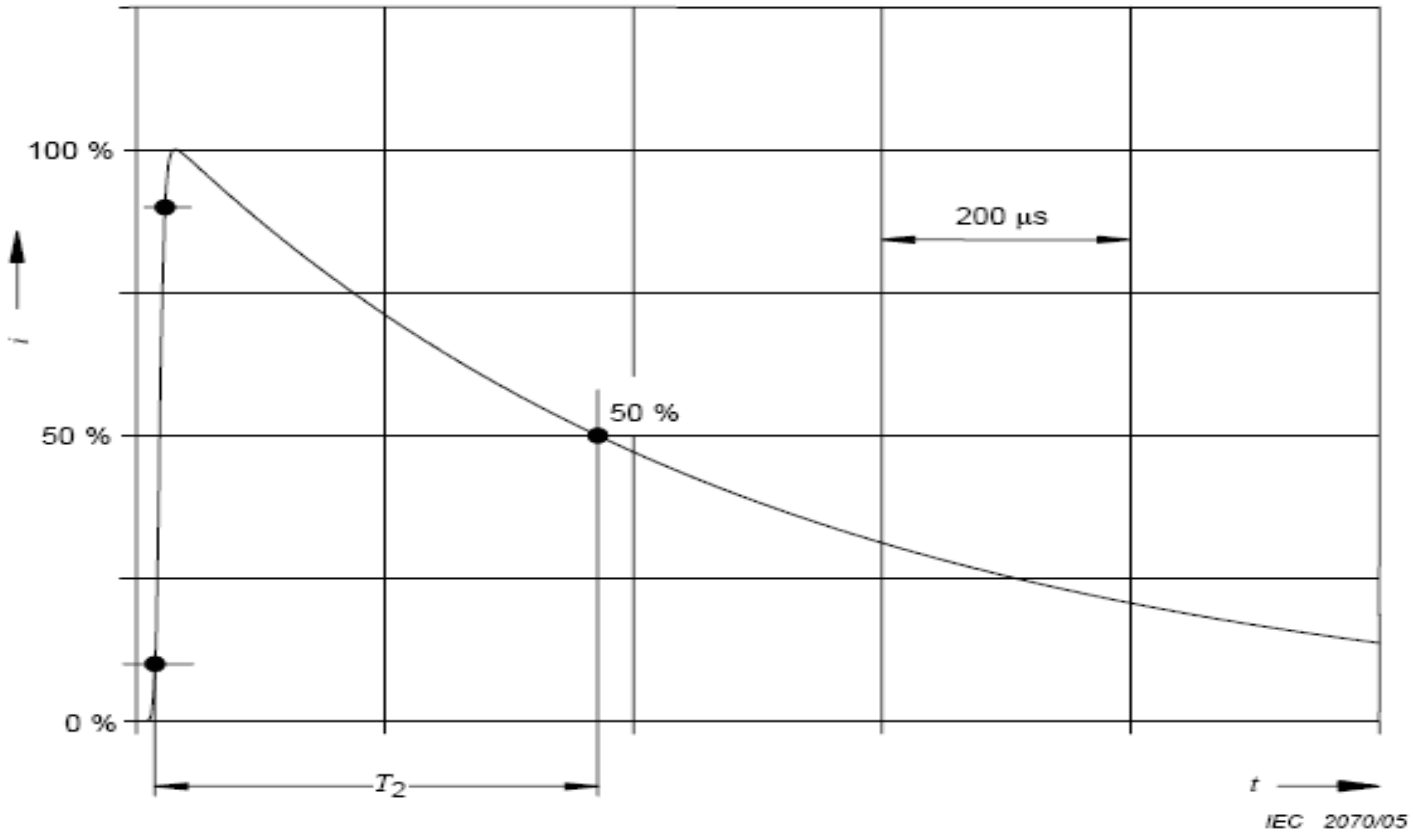
Direct Lightning Waveform

- IEC considers worst case
- 100% current 200kA
- 10%-90% risetime 10us
- 50% decay 350us
- 10/350us waveform

Waveform of the first stroke current



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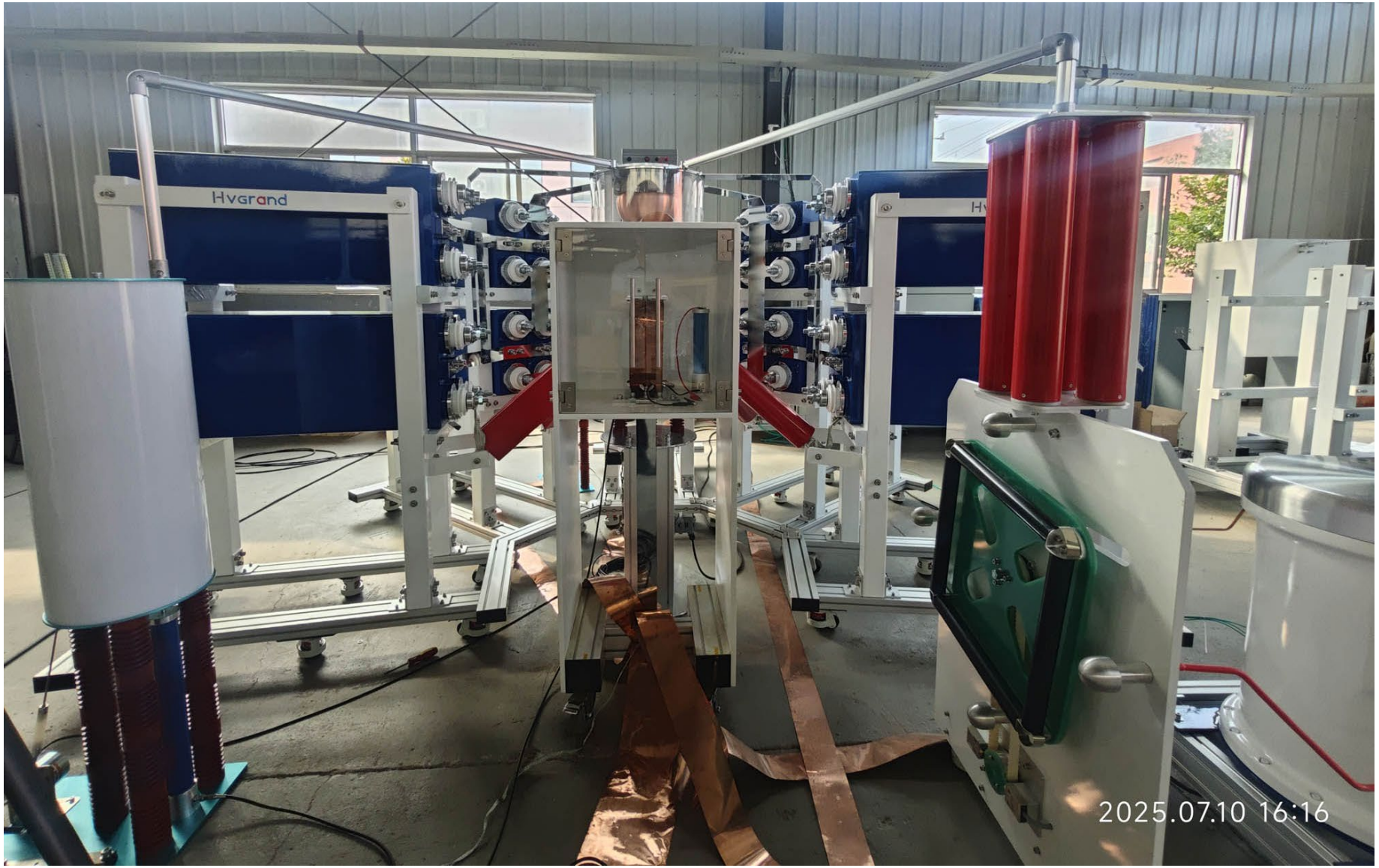
Novaris Surge Generator - Malaysia

- 200kA 8/20us
- 50kA 10/350us
- Largest in SE Asia



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Lightning Protection Level (LPL)

Maximum values of lightning parameters according to LPL

LPL	Efficiency
I	99%
II	97%
III	91%
IV	84%

From Table 5 IEC 62305-1

First short stroke			LPL			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	200	150	100	
Short stroke charge	Q_{short}	C	100	75	50	
Specific energy	W/R	MJ/Ω	10	5,6	2,5	
Time parameters	T_1/T_2	μs/μs	10 / 350			
Subsequent short stroke			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Peak current	I	kA	50	37,5	25	
Average steepness	di/dt	kA/μs	200	150	100	
Time parameters	T_1/T_2	μs/μs	0,25 / 100			
Long stroke			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Long stroke charge	Q_{long}	C	200	150	100	
Time parameter	T_{long}	s	0,5			
Flash			**LPL**			
Current parameters	**Symbol**	**Unit**	**I**	**II**	**III**	**IV**
Flash charge	Q_{flash}	C	300	225	150	

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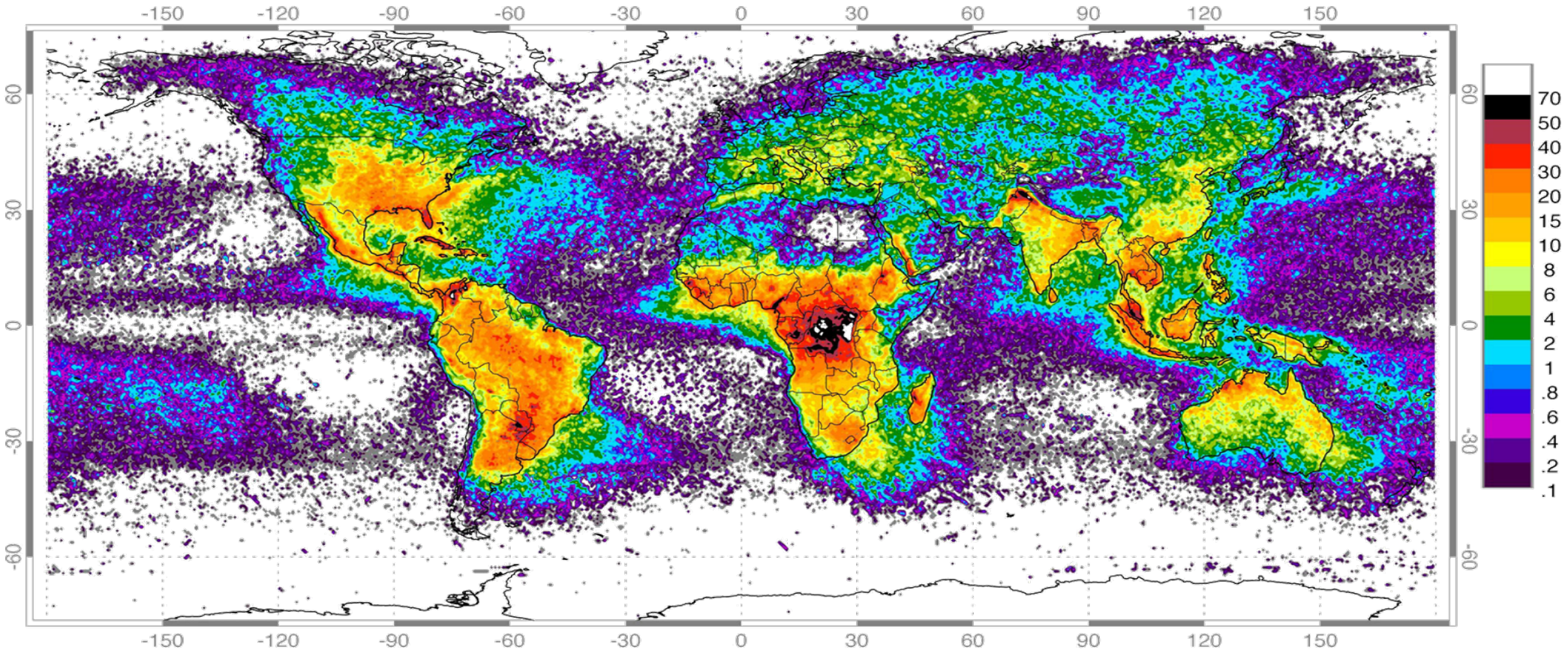
RISK ASSESSMENT

Flash Density - N_g



High Resolution Full Climatology Annual Flash Rate

Global distribution of lightning April 1995-February 2003 from the combined observations of the NASA OTD (4/95-3/00) and LIS (1/98-2/03) instruments

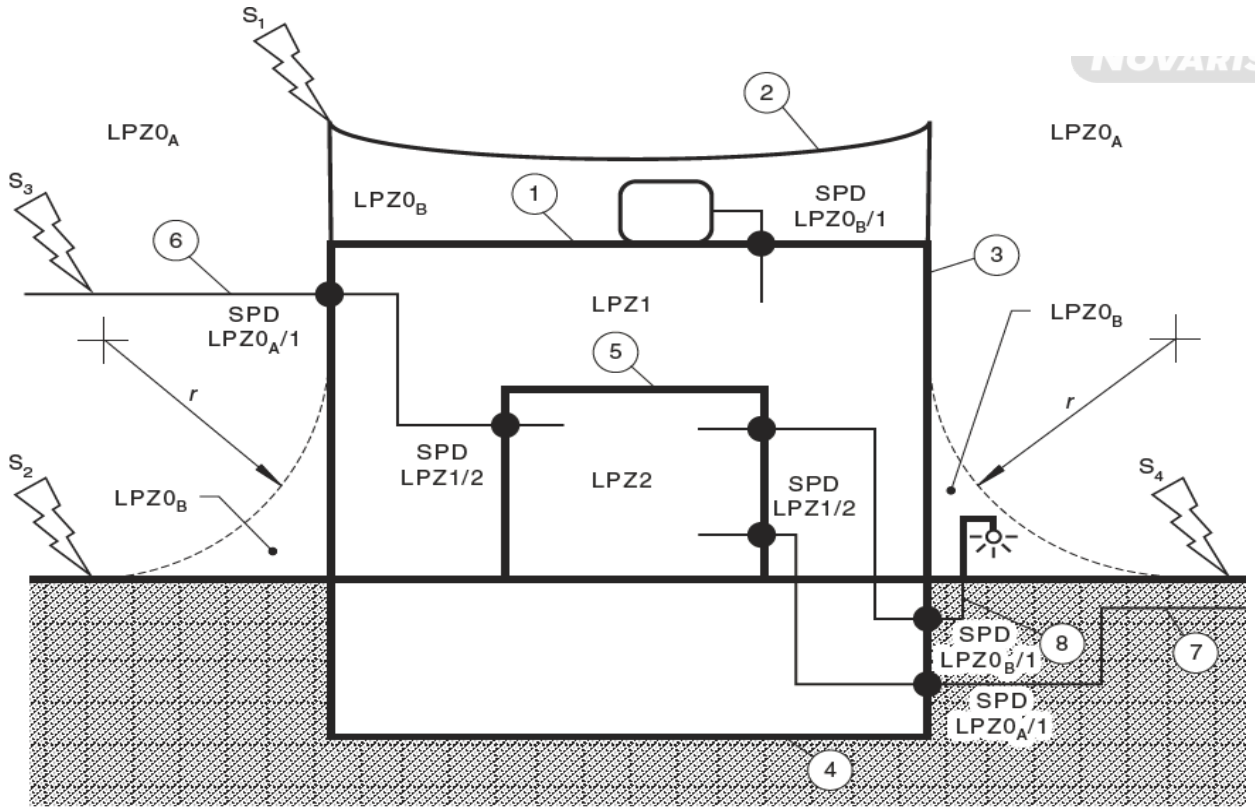
Sources of Damage

S1 – Flash to the structure

S2 – Flash near the structure

S3 – Flash to a service

S4 – Flash near a service



Key

1 Structure, boundary of $LPZ0_A/1$ and/or $LPZ0_B/1$
2 Air termination network
3 Downconductor network
4 Earth termination system
5 Boundary of LPZ1/2
6 Incoming overhead metallic services to structure
7 Incoming underground metallic services to structure
8 Outdoor electrical service in $LPZ0_B$

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AS 1768 Risk Assessment for Lightning Protection

Version 5.0 Date: 4/3/2020

Structure *WTP Water Treatment Plant*

Structure Dimensions

Length (m)	200
Width (m)	200
Height (m)	10

Structure Attributes

Susceptibility to Fire and Physical Damage	Low
Susceptibility to Electrical Sparking	Low
Internal Wiring Type	Unscreened

Environment

Ground Flash Density	15
Environmental Factor	Isolated
Service Line Density	Suburban

Service Lines

Power Line

Power Supply	Overhead
Cable Type	Unscreened
Transformer at Structure	Transformer

Other Overhead Services

Number	0
Cable Type	Unscreened

Other Underground Services

Number	1
Cable Type	Unscreened

Loss Categories

Category 1 - Loss of Human Life

Evacuation Difficulties	1	Location Type - FIRE	0	Location Type - OVERVOLTAGES	0

Category 2 - Loss of Essential Services

Fire Damage Factor	0.1	Overvoltage Damage Factor	0.01

Category 3 - Loss of Cultural Heritage

Fire Damage Factor	0

Category 4 - Economic Loss

Fire Damage Factor	0.2	Tolerable Risk of Economic Losses	1.E-03
Overvoltage Damage Factor	1.E-04	Step & Touch Potential Damage Factors (Animals)	0

Protection Measures

Efficiency of Direct Strike Protection	0	Surge Protection at Point of Entry	No
Fire Protection	Automated	Surge Protection on All Equipment	No

Lightning Strike Frequencies

Direct strikes to STRUCTURE per annum	1.002
Years between direct strikes to STRUCTURE	1.0
Indirect strikes to STRUCTURE per annum	5.54
Years between indirect strikes to STRUCTURE	0.2
Direct strikes to SERVICES per annum	0.203
Years between direct strikes to SERVICES	4.9
Indirect strikes to SERVICES per annum	11.72
Years between indirect strikes to SERVICES	0.1

Overall Risk

	Calculated Risk (R)	Tolerable Risk (Ra)	Direct Strike Risk (Rd)	Indirect Strike Risk (Ri)
Loss of Human Life	2.00E-05	1.0E-05	2.00E-05	5.11E-11
Loss of Essential Services	5.92E-02	1.0E-03	1.01E-02	4.91E-02
Loss of Cultural Heritage	0.00E+00	1.0E-03	0.00E+00	0.00E+00
Economic Loss	7.42E-04	1.0E-03	2.45E-04	4.97E-04

AS 1768 Risk Assessment for Lightning Protection

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Other Underground Services

Number	1
Cable Type	Unscreened

Loss Categories

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Evacuation Difficulties	1	Location Type - FIRE	0	Location Type - OVERVOLTAGES	0

Category 2 - Loss of Essential Services

Fire Damage Factor	0.1	Overvoltage Damage Factor	0.01

Category 3 - Loss of Cultural Heritage

Fire Damage Factor	0

Category 4 - Economic Loss

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Overvoltage Damage Factor	1.E-04	Step & Touch Potential Damage Factors (Animals)	0

Protection Measures

Efficiency of Direct Strike Protection	0.84	Surge Protection at Point of Entry	Yes
Fire Protection	Automated	Surge Protection on All Equipment	Yes

Lightning Strike Frequencies

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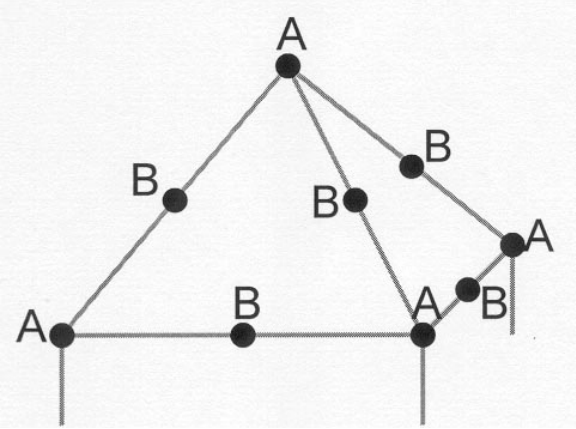
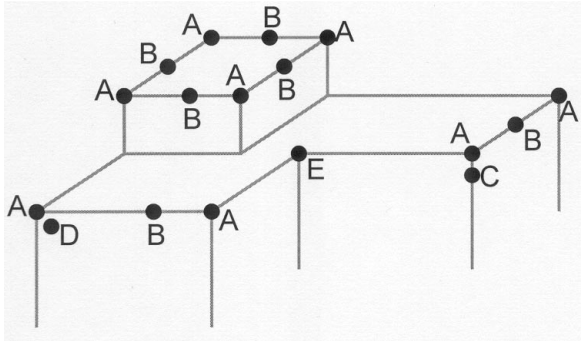
Overall Risk

	Calculated Risk (R)	Tolerable Risk (Ra)	Direct Strike Risk (Rd)	Indirect Strike Risk (Ri)
Loss of Human Life	3.21E-06	1.0E-05	3.21E-06	5.11E-13
Loss of Essential Services	2.83E-05	1.0E-03	6.74E-06	2.16E-05
Loss of Cultural Heritage	0.00E+00	1.0E-03	0.00E+00	0.00E+00
Economic Loss	5.37E-06	1.0E-03	5.09E-06	2.77E-07

Lightning Strike Points - Hartono





Lightning Damage Location	2000	1995
(A) Sharp points/corners	>90%	>80%
(B) Horizontal/slant edges	<5%	<10%
(C) Vertical edges	<2%	<5%
(D) Flat surface [near A]	<1%	<5%
(E) Other locations	0%	N/A

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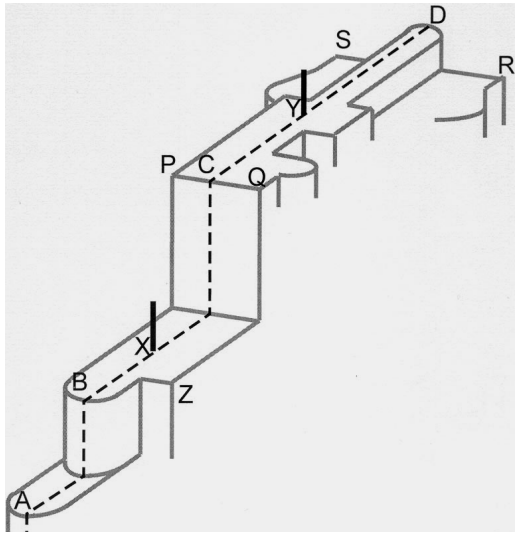
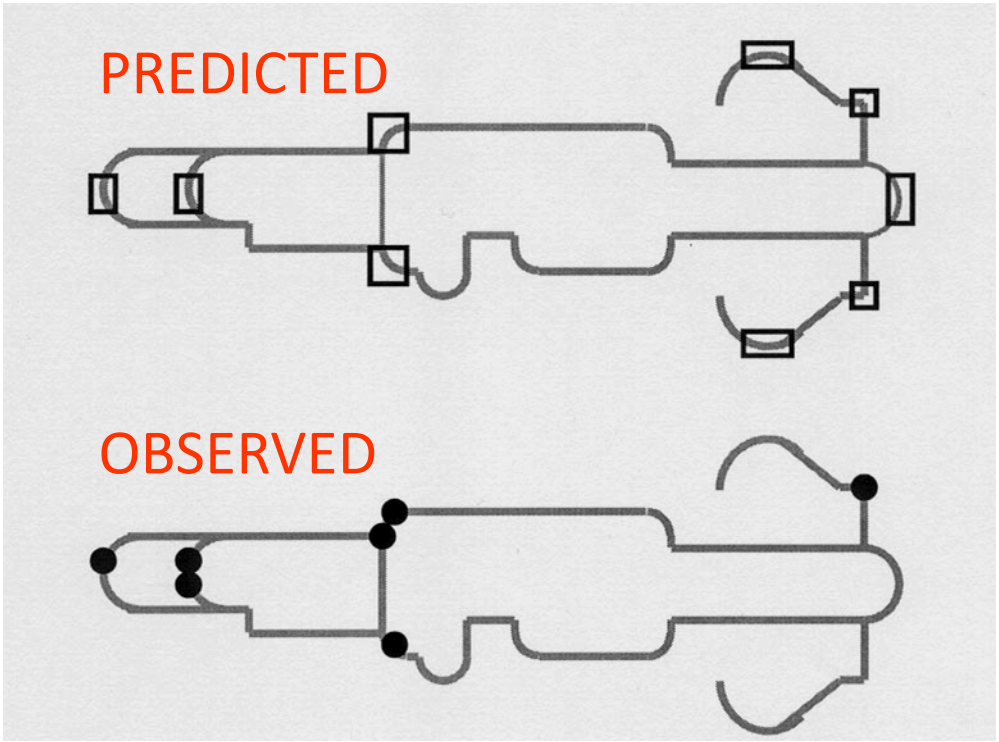
Lightning Strike Points - Hartono





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Lightning Strike Points - Hartono

AS1768 - Air Terminal Placement

Place air terminals as follows:

1. Place air terminals on the points and corners
2. Use the rolling sphere on the sides
3. Relax the rolling sphere to 2 times radius for large flat surfaces

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Downconductors – use the structure

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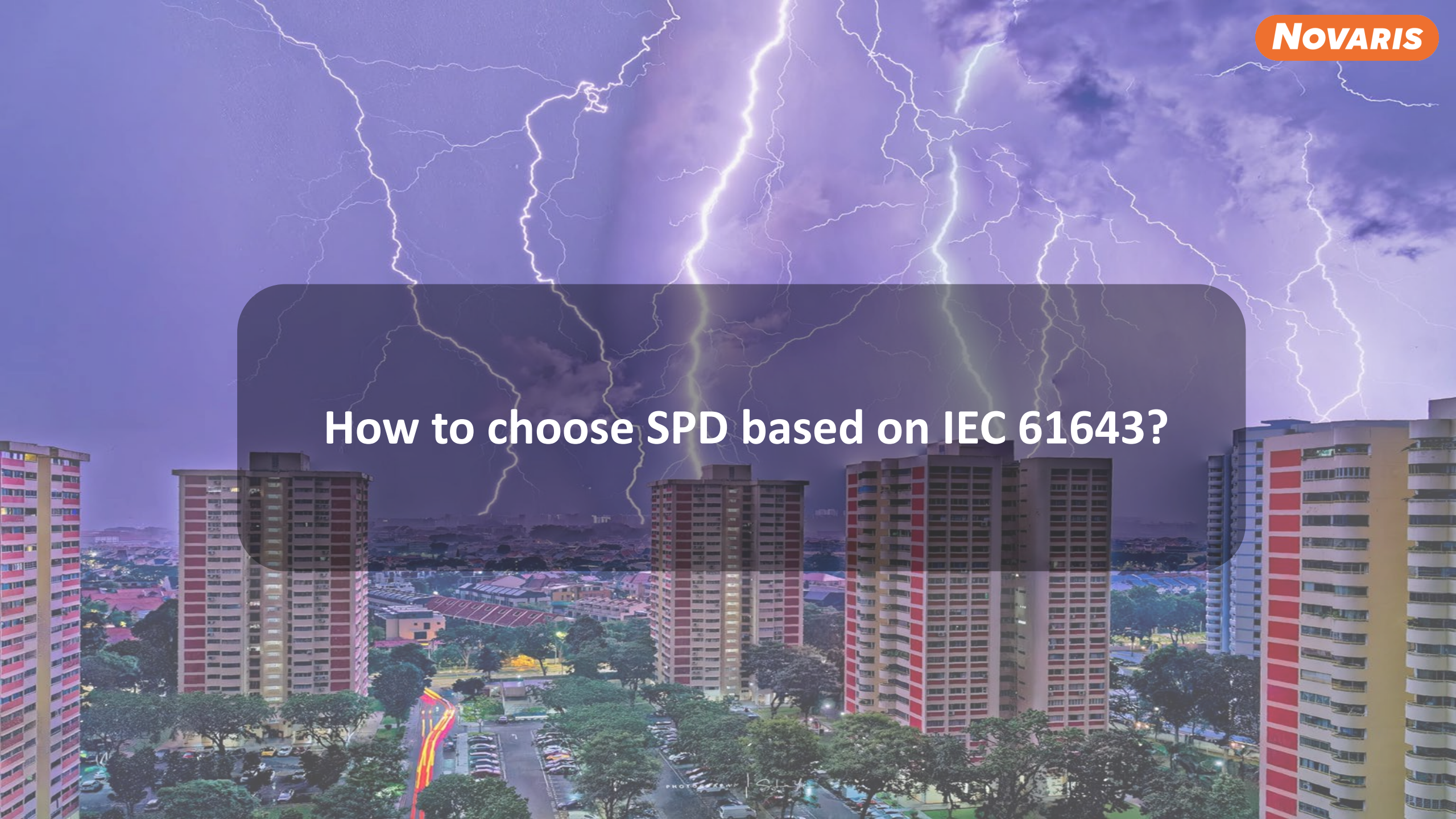
Earthing

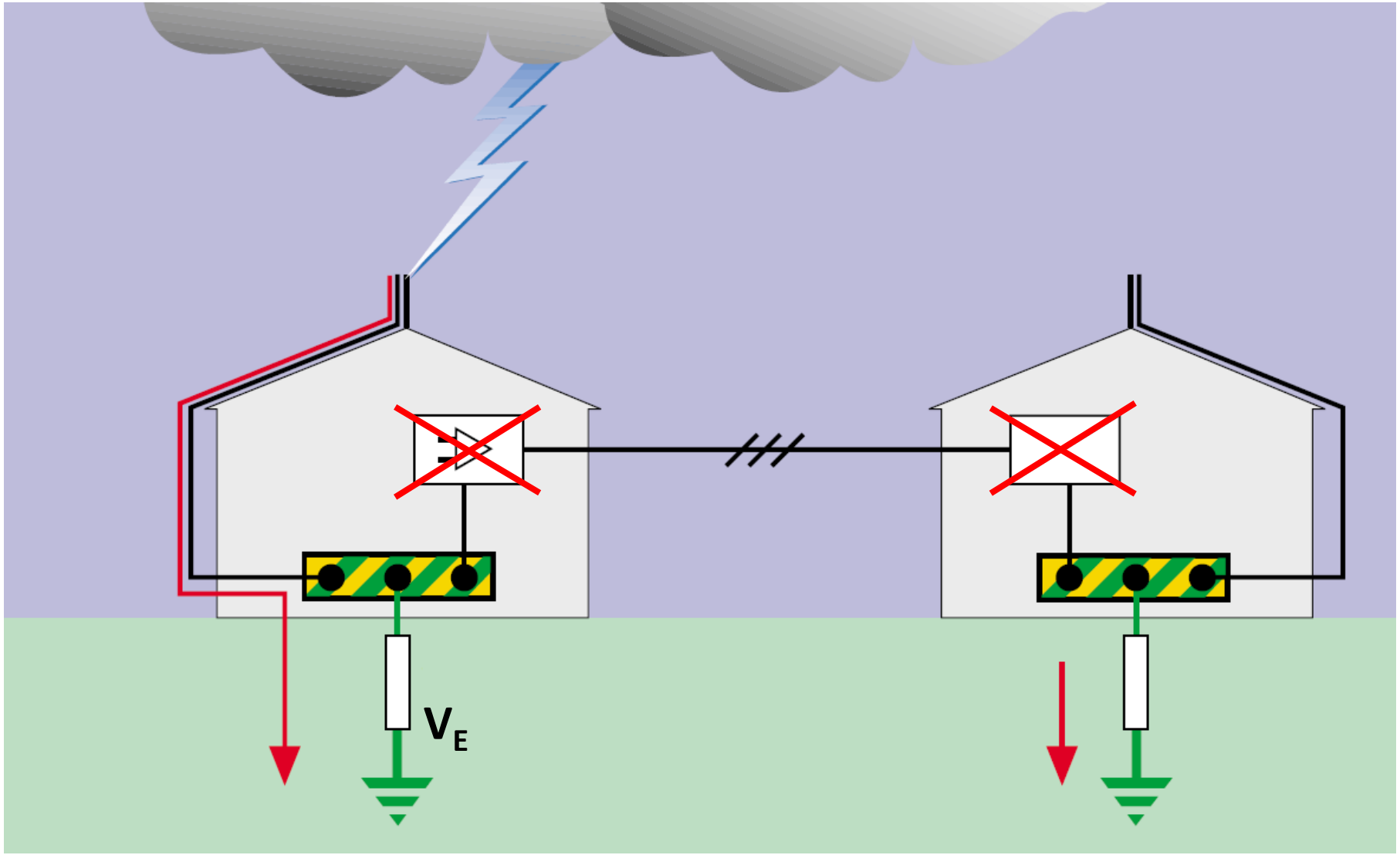


How to choose SPD based on IEC 61643?

Surge Protection

Indirect Effects

- **Earth Potential Rise**
- Electric Field
- Magnetic Field
- Protected



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Surge Protection

Indirect Effects

- Earth Potential Rise
- **Electric Field**
- Magnetic Field
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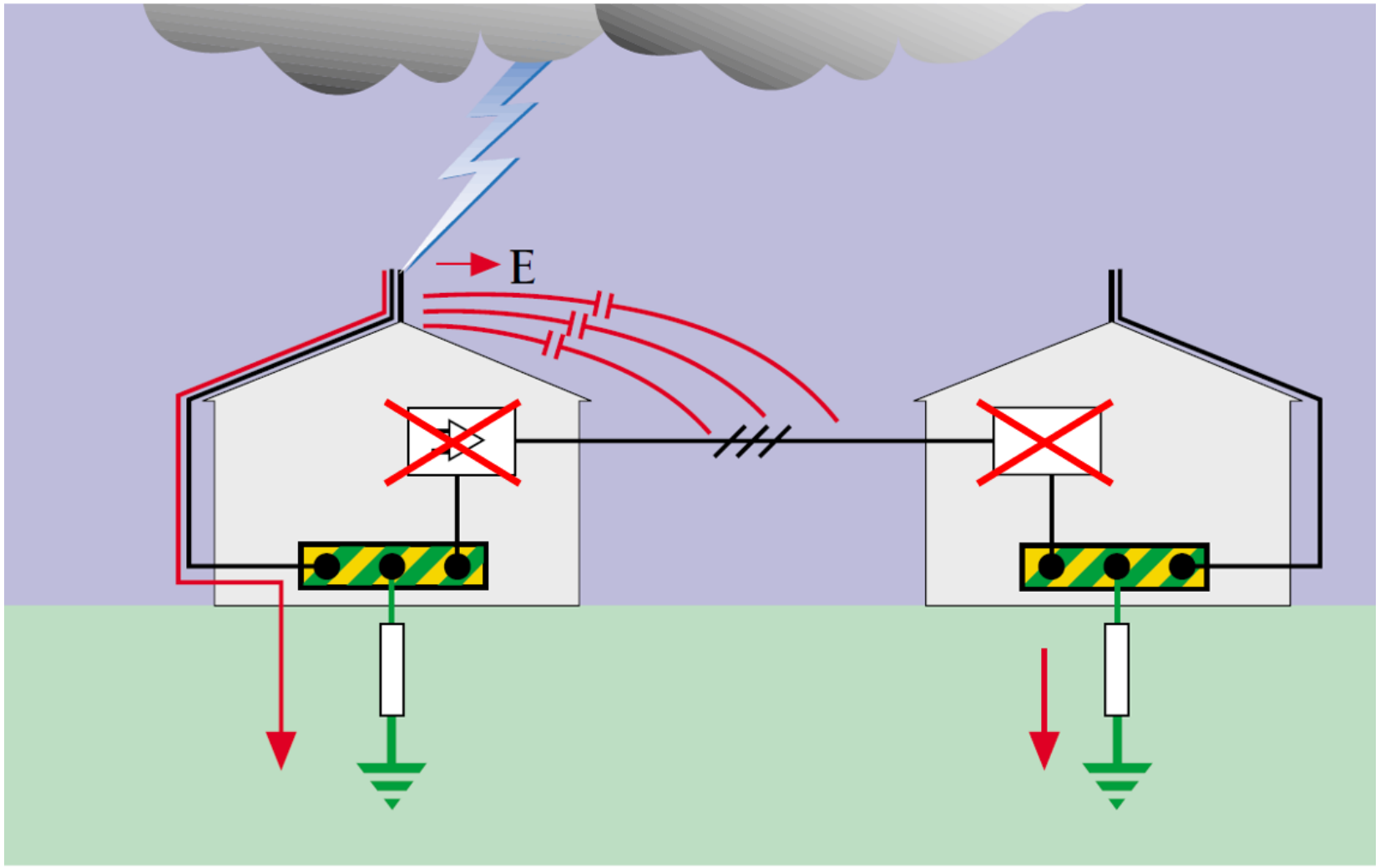

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Surge Protection

Indirect Effects

- Earth Potential Rise
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- **Magnetic Field**
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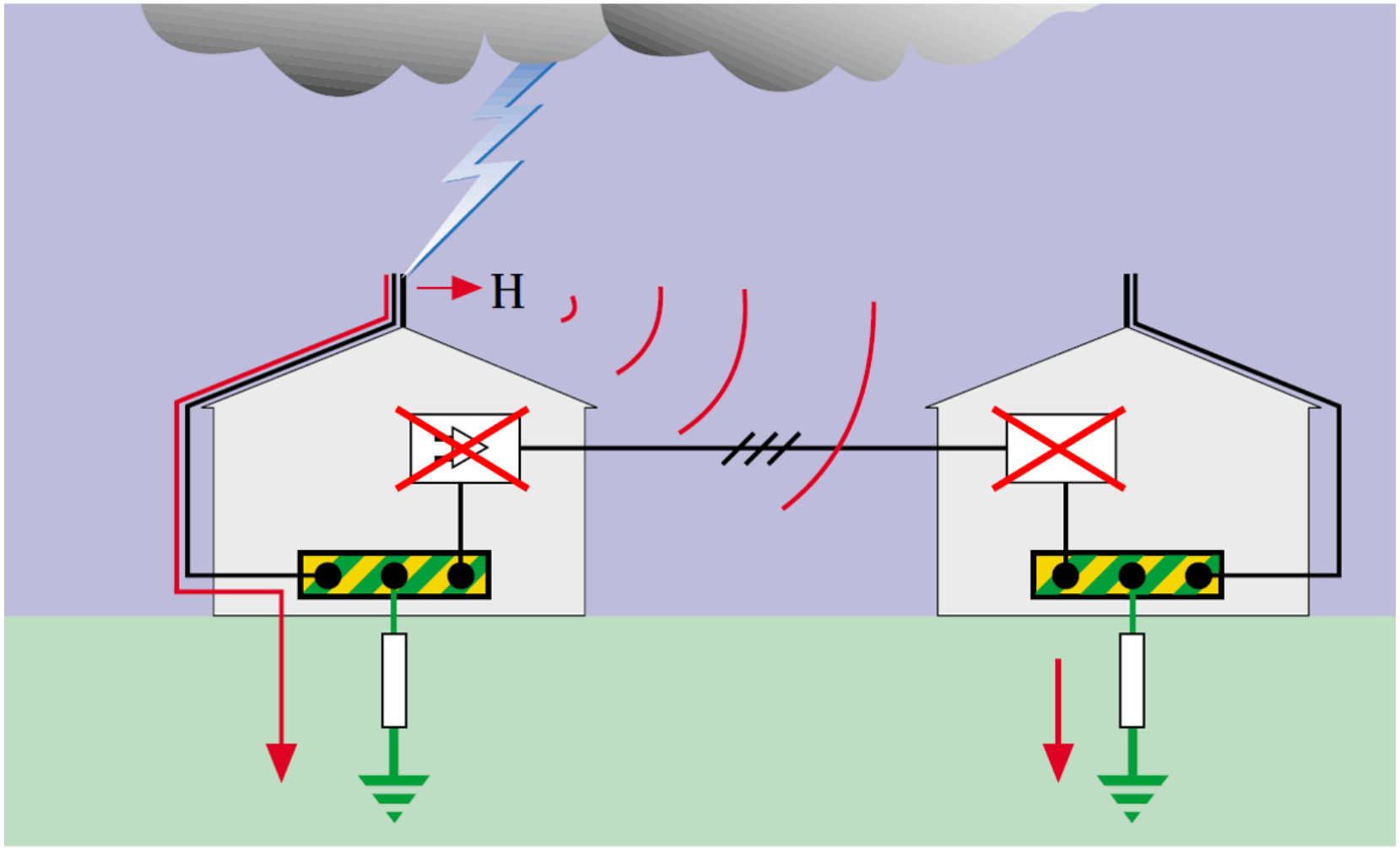

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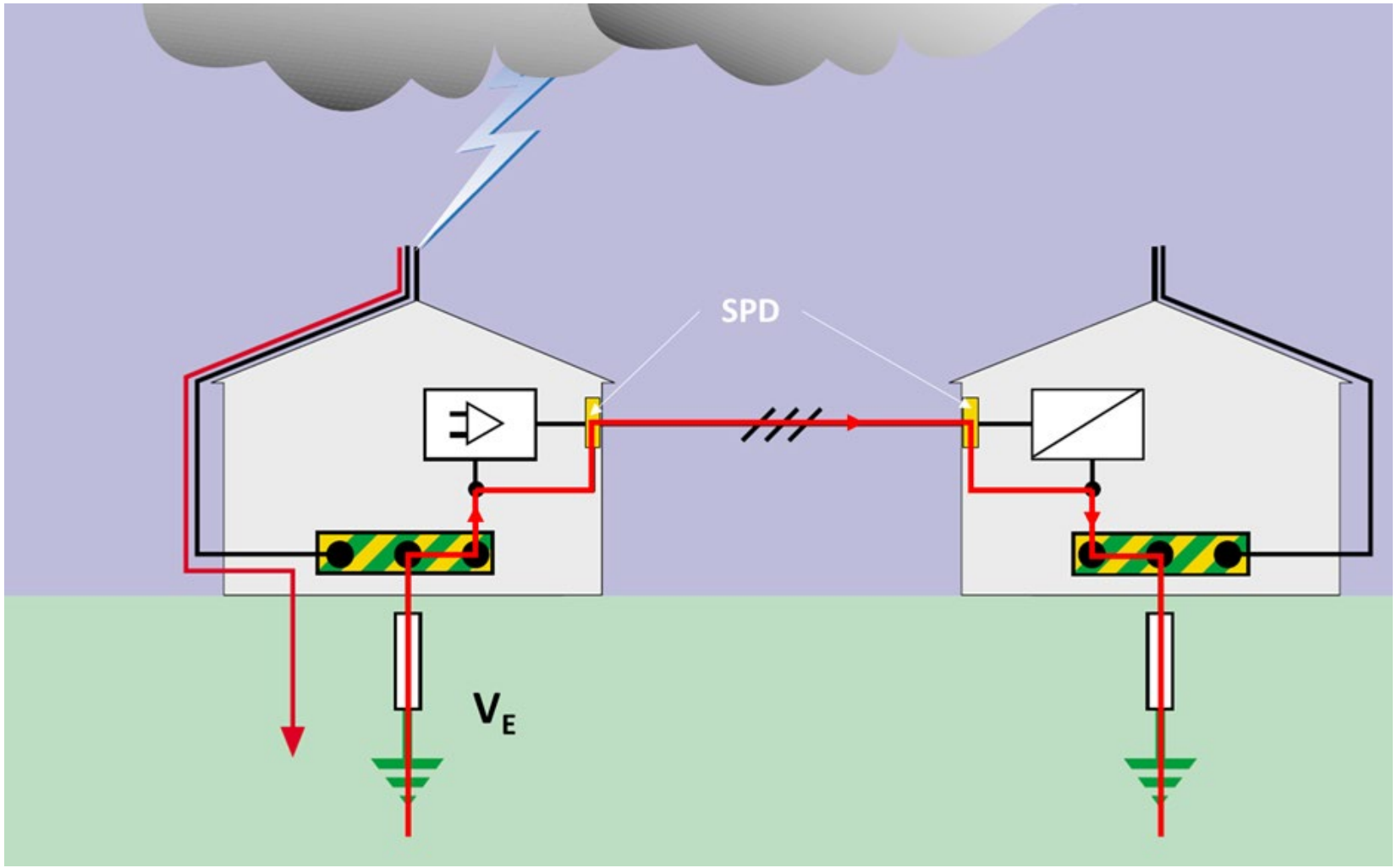
Surge Protection

Indirect Effects

- Earth Potential Rise
- Electric Field
- Magnetic Field
- **Protected**



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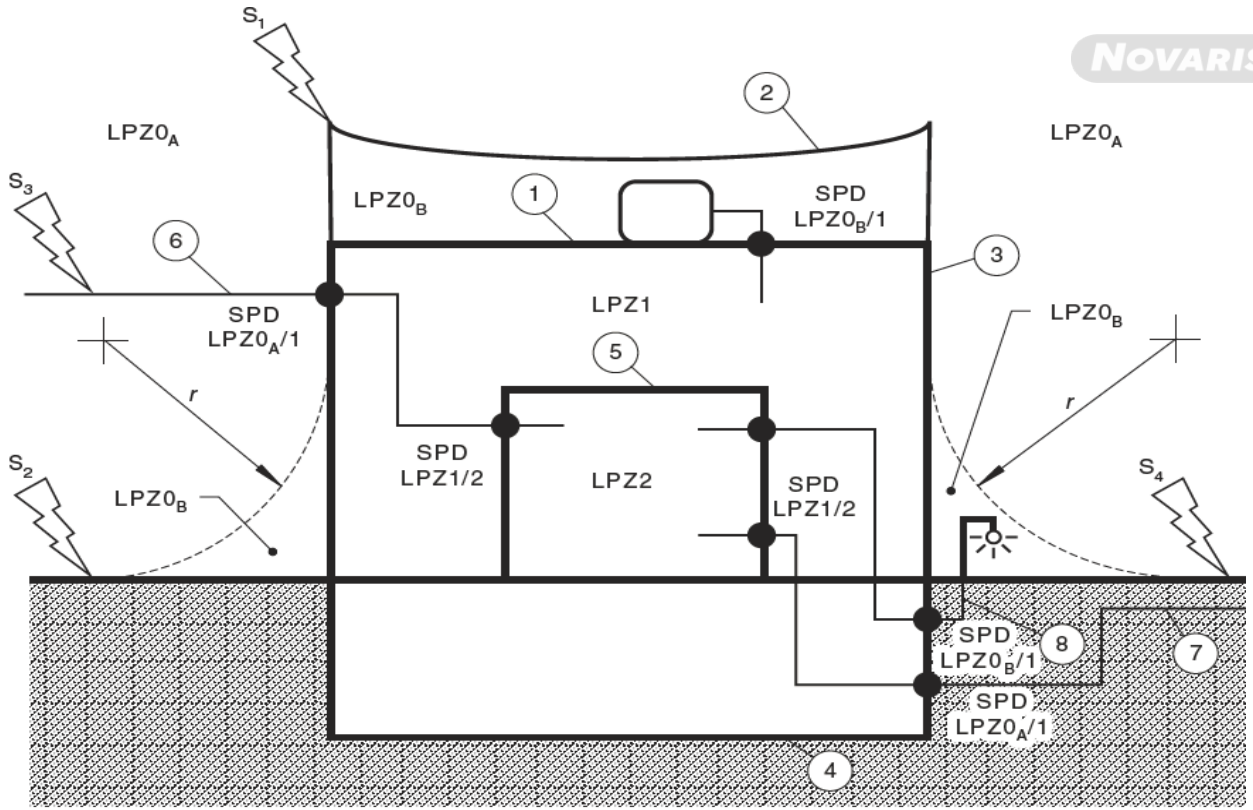
Lightning Protection Zones (LPZ)

Lightning Protection Zone concept

- LPZ 0_A
- LPZ 0_B
- LPZ 1
- LPZ 2



Key

1 Structure, boundary of $LPZ0_A/1$ and/or $LPZ0_B/1$
2 Air termination network
3 Downconductor network
4 Earth termination system
5 Boundary of LPZ1/2
6 Incoming overhead metallic services to structure
7 Incoming underground metallic services to structure
8 Outdoor electrical service in $LPZ0_B$

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Lightning Protection Zones (LPZ)

LPZ	Definition
• **LPZ 0_A**	Zone where the threat is due to the direct lightning flash and the full lightning electromagnetic field.
• **LPZ 0_B**	Zone protected from the direct lightning flash but where the threat is the full lightning electromagnetic field.
• **LPZ 1**	Zone where the surge current is limited by current sharing and by SPDs at the boundary.
• **LPZ 2, …,n**	Zones where the surge current may be further limited by current sharing and by additional SPDs at the boundary.

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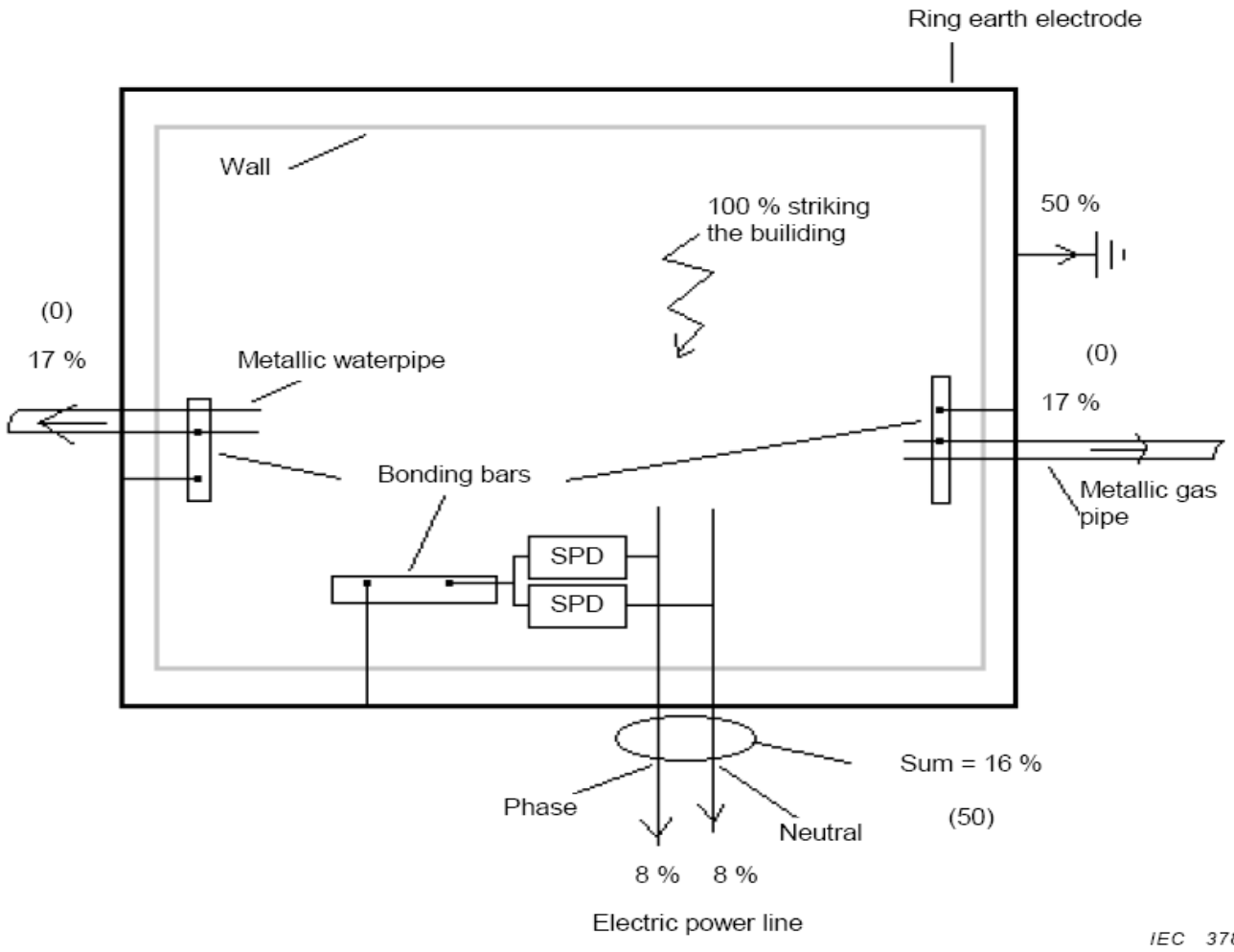
Lightning Strike to Building

- By calculation
- Assume 50% to earth
- 50% to services
- Equal division to each service
- Equal division to each conductor
- From IEC61643-12



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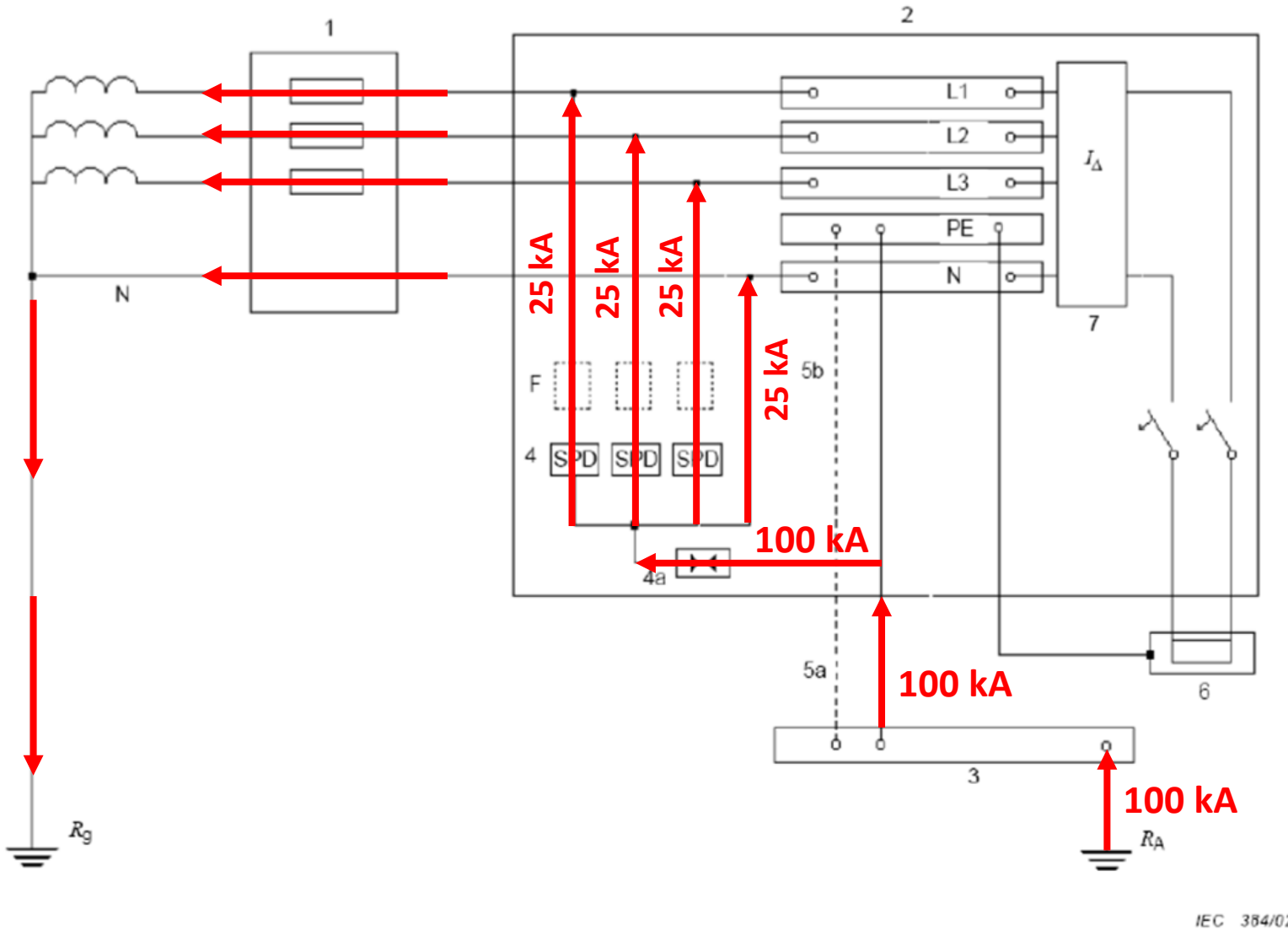
Surge Protection Ratings – TT Systems

Lightning strike to building TT Syste

- Assume only Power
- Assume 50% to earth
- 50% to services
- 50% through 4a
- 12.5% to each SPD, 4 and neutral
- IEC CT2 configuration



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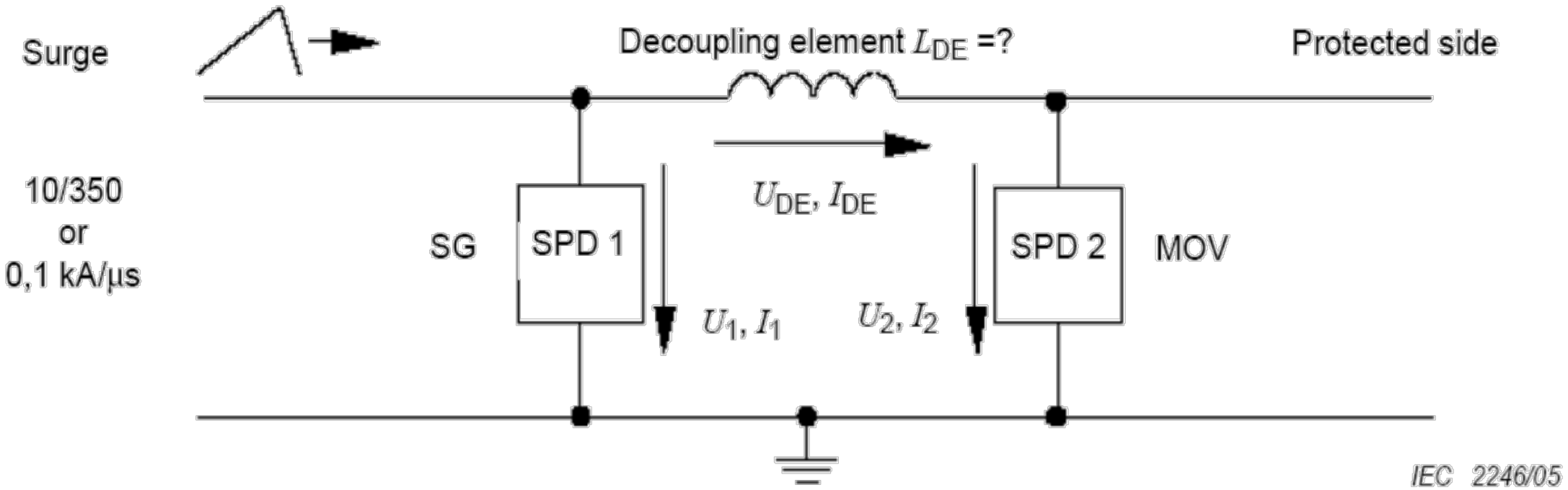
SPD Coordination



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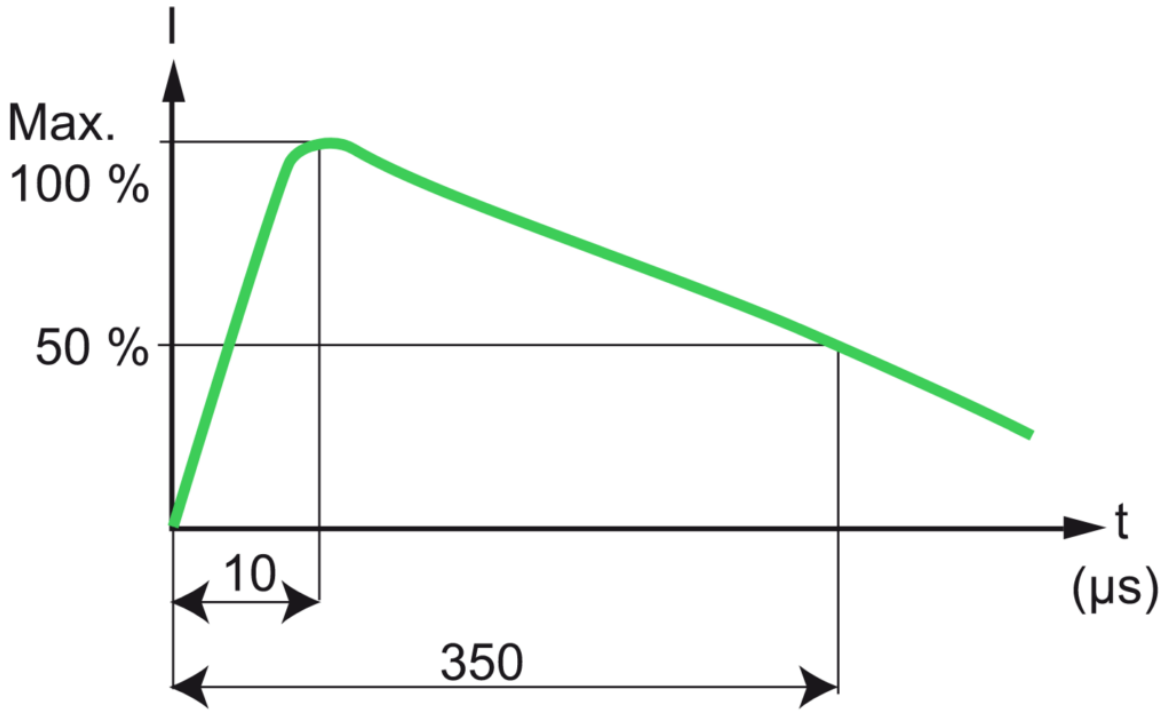
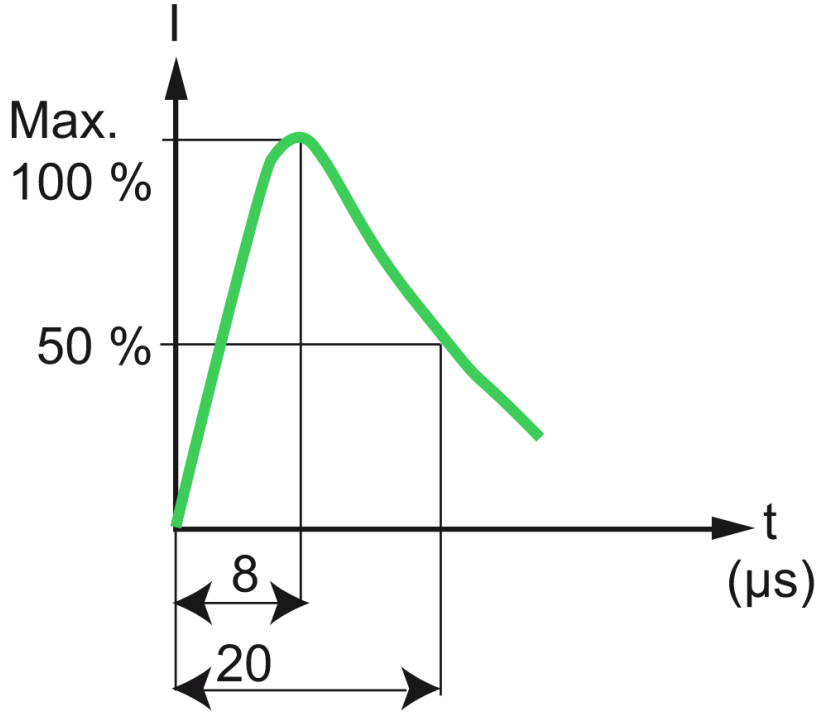
Surge Waveforms

Type 1(10/350µs)
Direct Strike



Type 2 (8/20µs)
Indirect Strike



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Power SPD Ratings (per phase)

Table 4.1: Surge ratings for a.c. power system SPDs per phase – MEN (TN-C-S) systems and other TN, TT and IT systems

Zone boundary	Location category[a]	SPD location	I_{max} rating, 8/20µs, kA	I_n rating, 8/20µs, kA	I_{imp} rating, 10/350µs, kA
LPZ2/…n	A	Long final subcircuits and supply outlets	3 to 10	2 to 5	-
LPZ1/2	B	Major submains, short final subcircuits and load centres	40	20	-
$LPZ0_B/1$	C1	Domestic service entrance or external services shielded from direct lightning strike	40	20	5
$LPZ0_A/1$	C2	Industrial or commercial service entrance, building fed by long overhead or underground conductive services	100	40	10
$LPZ0_A/1$[b]	C3	Service entrance, building in a high lightning area (N_g greater than 2), or fitted with an LPS	100	40	10

Not all SPDs specify their I_{max}, I_n, and I_{imp} ratings. An SPD conforming to any one of these ratings shall be deemed to conform.

[a] The term location category has been defined in previous editions of AS/NZS 1768. It is shown here for the purposes of clarity.

[b] In high lightning areas (e.g. in tropical regions, at mountaintop telecommunication and broadcasting sites with long overhead powerlines), it may be prudent to consider higher surge ratings for the primary SPD to provide a longer service life.

Table is based on IEC61643 and AS1768:2021

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Data and Signal SPD Ratings

Table 4.2: Surge ratings for signal/data line SPDs[a]

Zone boundary	Location category	SPD location	I_{TOT} rating, 8/20µs, kA	I_{imp} rating, 10/350µs, kA
LPZ2/…n	A, B	Internal marshalling cubicle or equipment cabinet	1 to 5	-
$LPZ0_B/1$	C1	External signal cables shielded from direct lightning strike	5 to 10	0.5 to 1
$LPZ0_A/1$	C2	Point of entry, long overhead or underground signal cables	10 to 20	1 to 2.5
$LPZ0_A/1$[b]	C3	Point of entry signal cables, building in a high lightning area (N_g greater than 2), or fitted with an LPS	10 to 20	1 to 2.5

Not all SPDs specify their I_{TOT} and I_{imp} ratings. An SPD conforming to any one of these ratings shall be deemed to conform.

[a] Most signal lines are paired cables and the primary protection is frequently provided by gas discharge tubes. The I_{TOT} and I_{imp} ratings here relate to the rating from both lines to earth, referred to as X1/Y1 – C.

Table is based on IEC61643 and AS1768:2021

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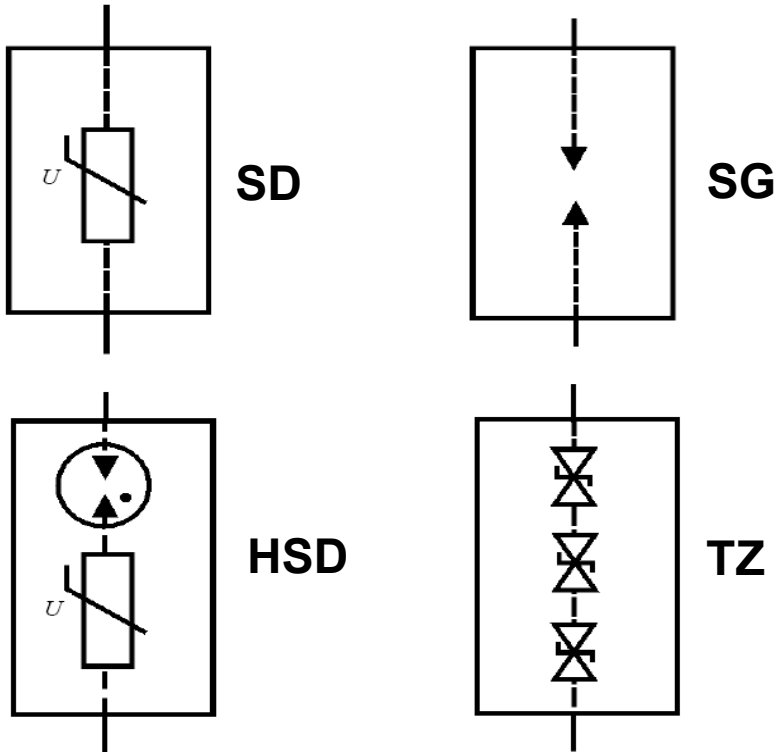
Conventional & Modern SPD technologies

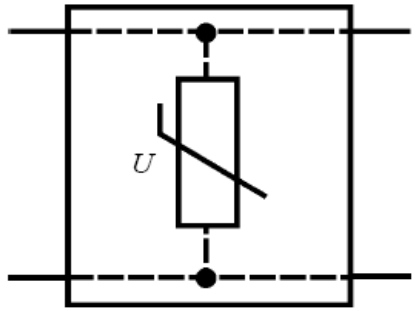
One Port vs Two Port SPDs

One port : Shunt connected
Surge Diverters (SD), Spark Gaps (SG),
Hyrbid Surge devices (HSD)



One-port SPDs

Two ports: Series connected, Separate input and output
Surge filters (SF) or Series Surge Protectors (SSP)

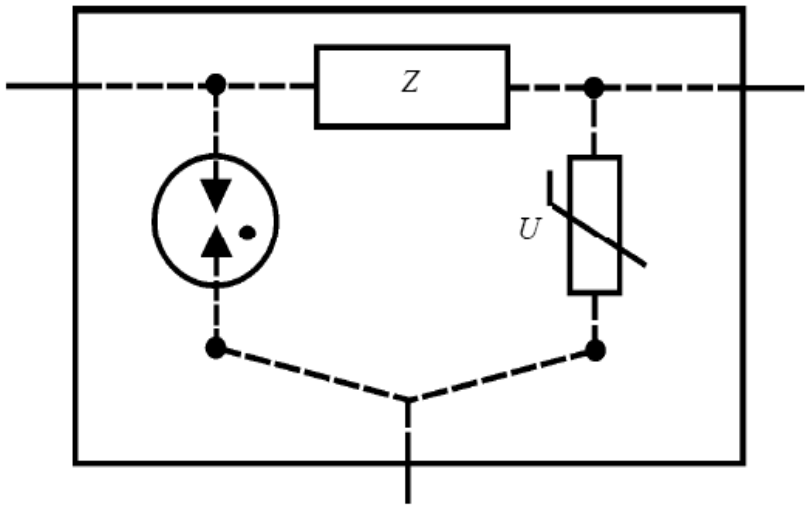


Two-port SPDs

Private and Confidential

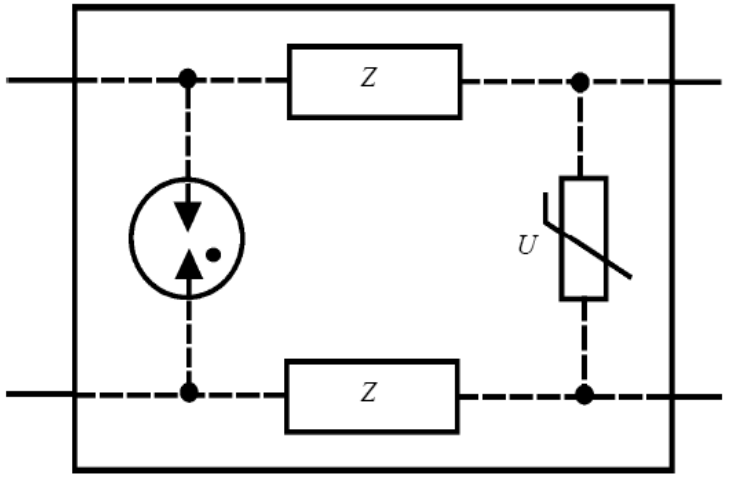
Two-Port SPDs

a) Series connected, three terminal SF



SF

b) Series connected, four terminal SF, SL

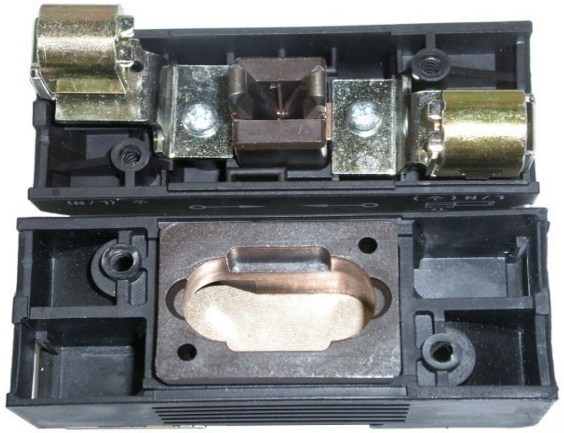


SF, SL

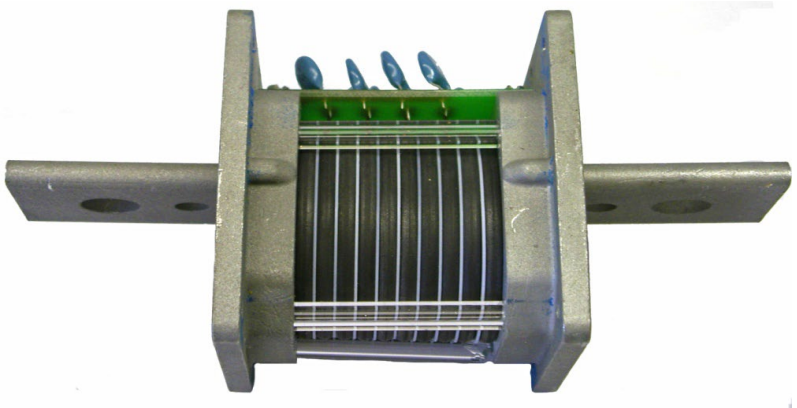
Private and Confidential

SPD for LPZ 0/1: L-N and N-PE Spark Gaps

- Designed for main switchboards
- High energy capability
- Robust
- Moderate let through voltage even for triggered units
- Can withstand 415V TOV
- Suffers Follow on current



Air gap electrodes



Carbon discs

Private and Confidential

AC Follow-on Current

SPD for LPZ 0/1: N-PE GDT

- Designed for main switchboards
- Very high energy capability
- Good let through voltage
- Reliable firing
- CANNOT withstand AC voltage

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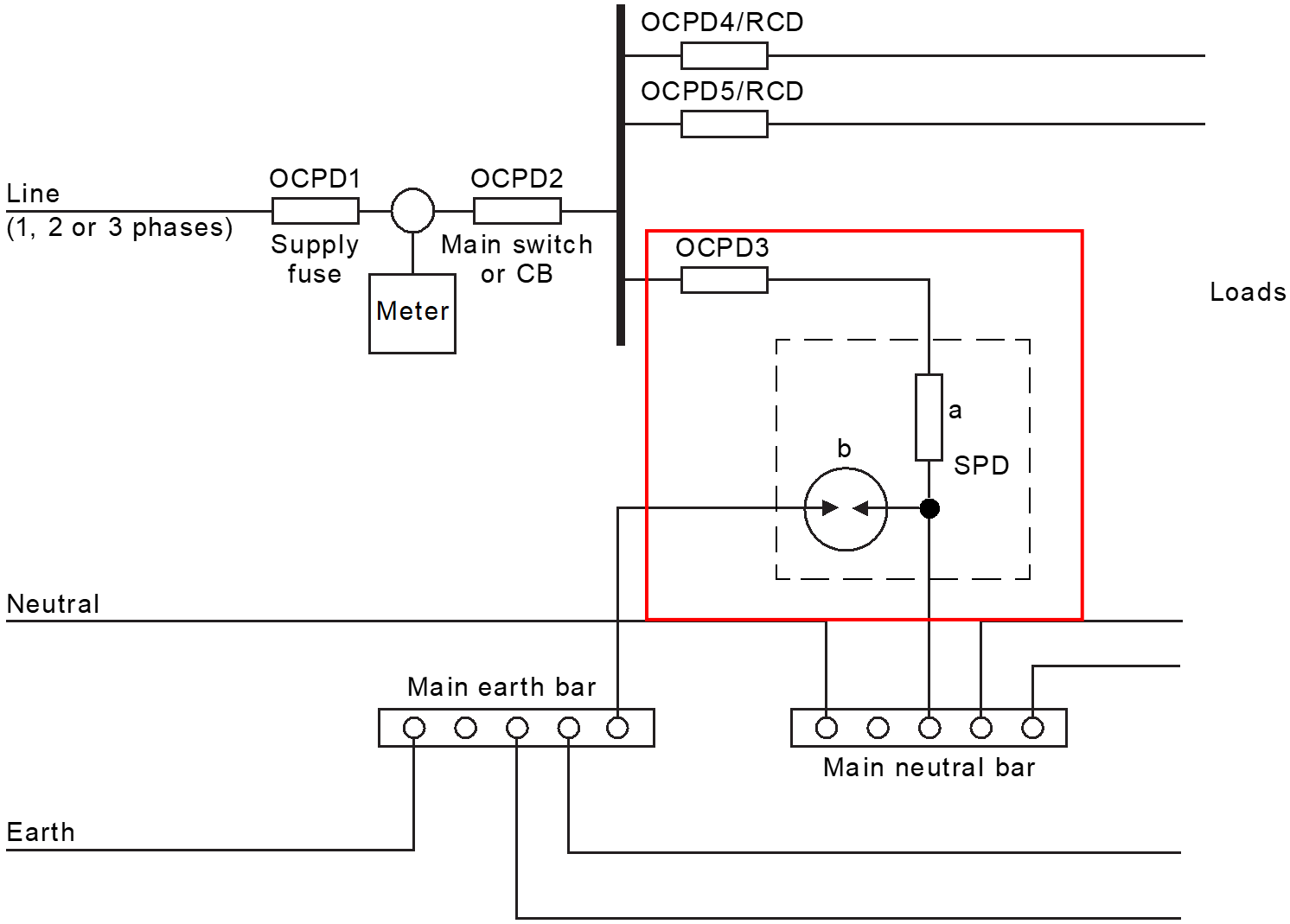
One-Port SPD Installation



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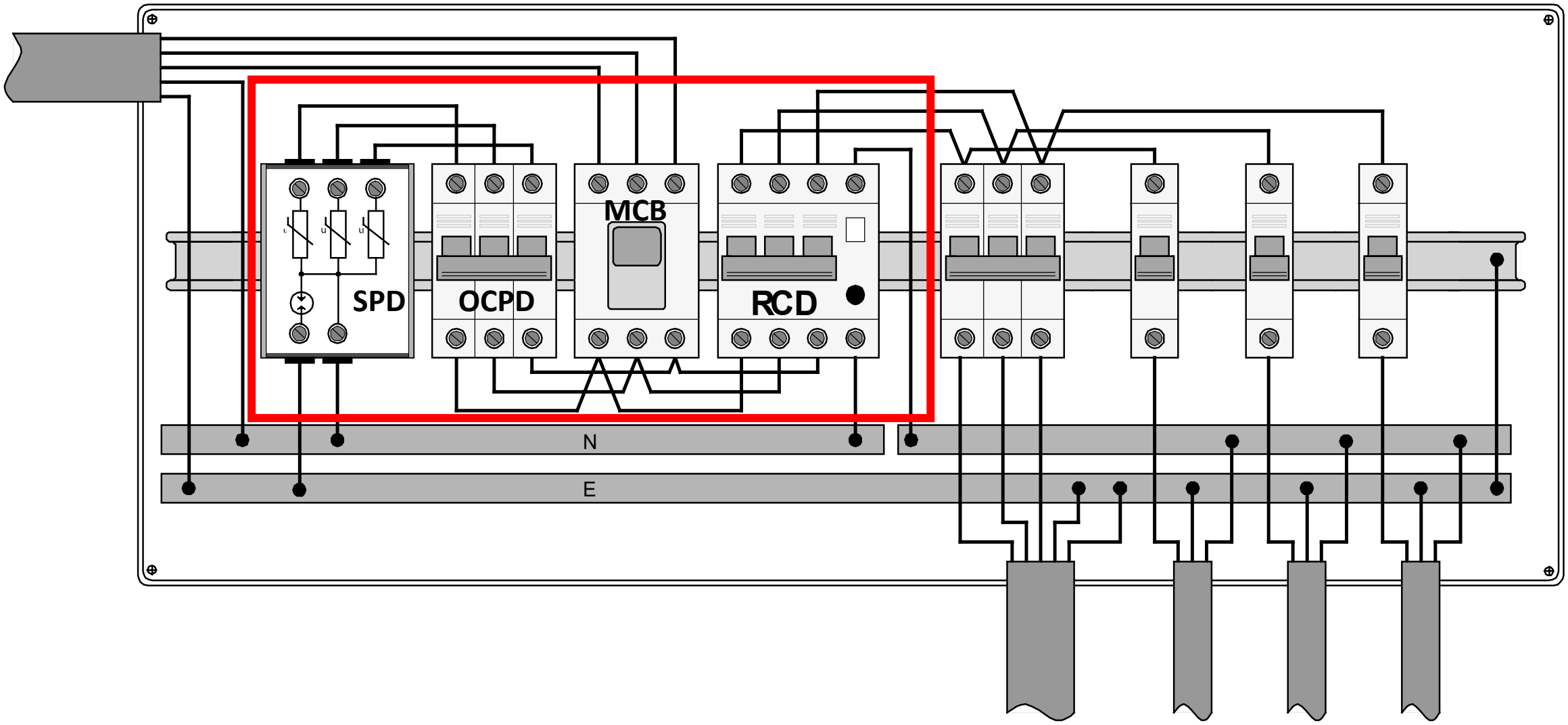
One-Port SPD Installation



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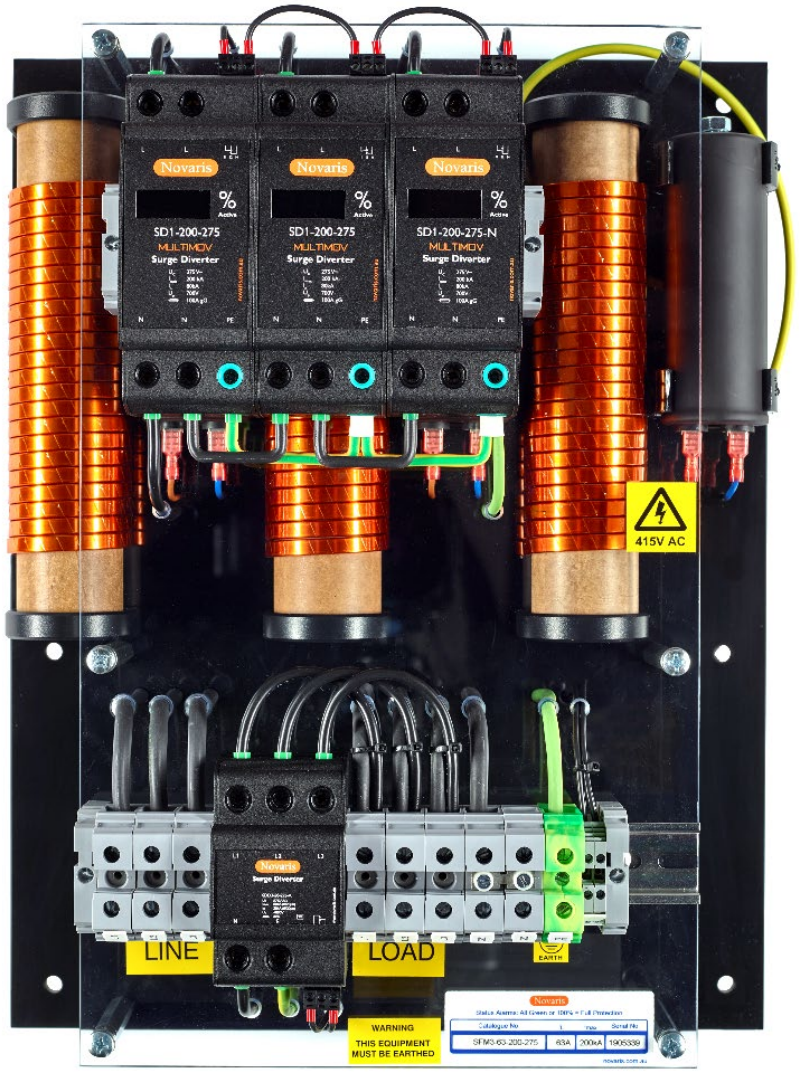
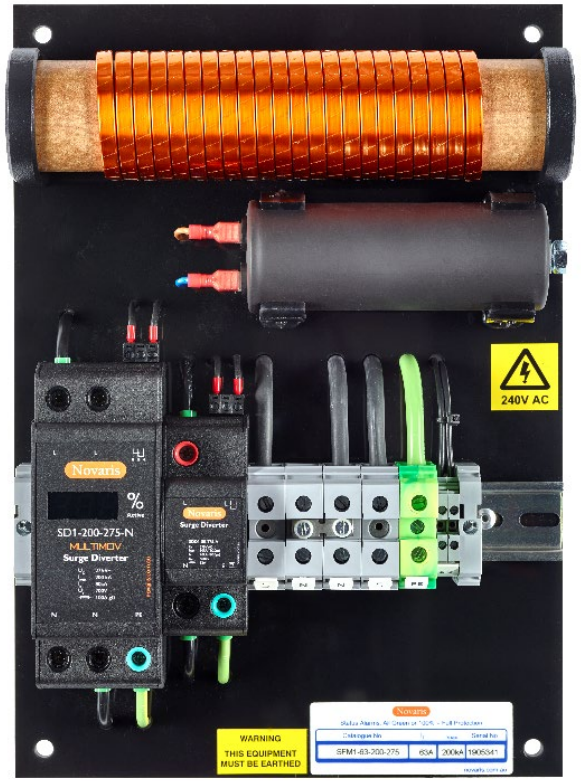
Multi MOVs

- Designed for main and sub boards
- 2 – 4 individually fused 50kA MOVs
- All mode
- External alarm
- Thermal sensing
- Safe metal enclosure
- LED or Digital display

Two-Port SPD – LPZ 0/1 Medium Current





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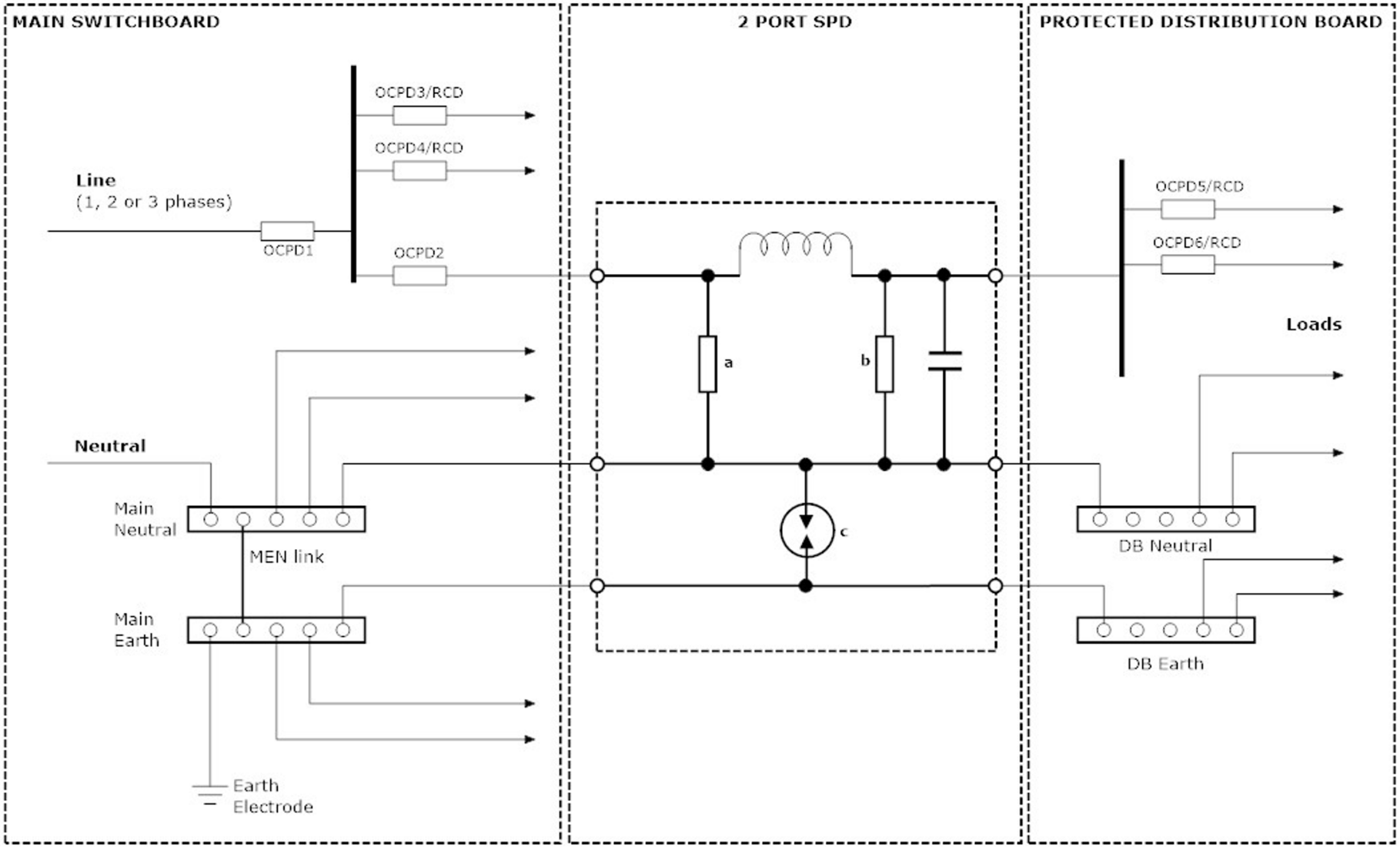
Two-Port SPD Installation



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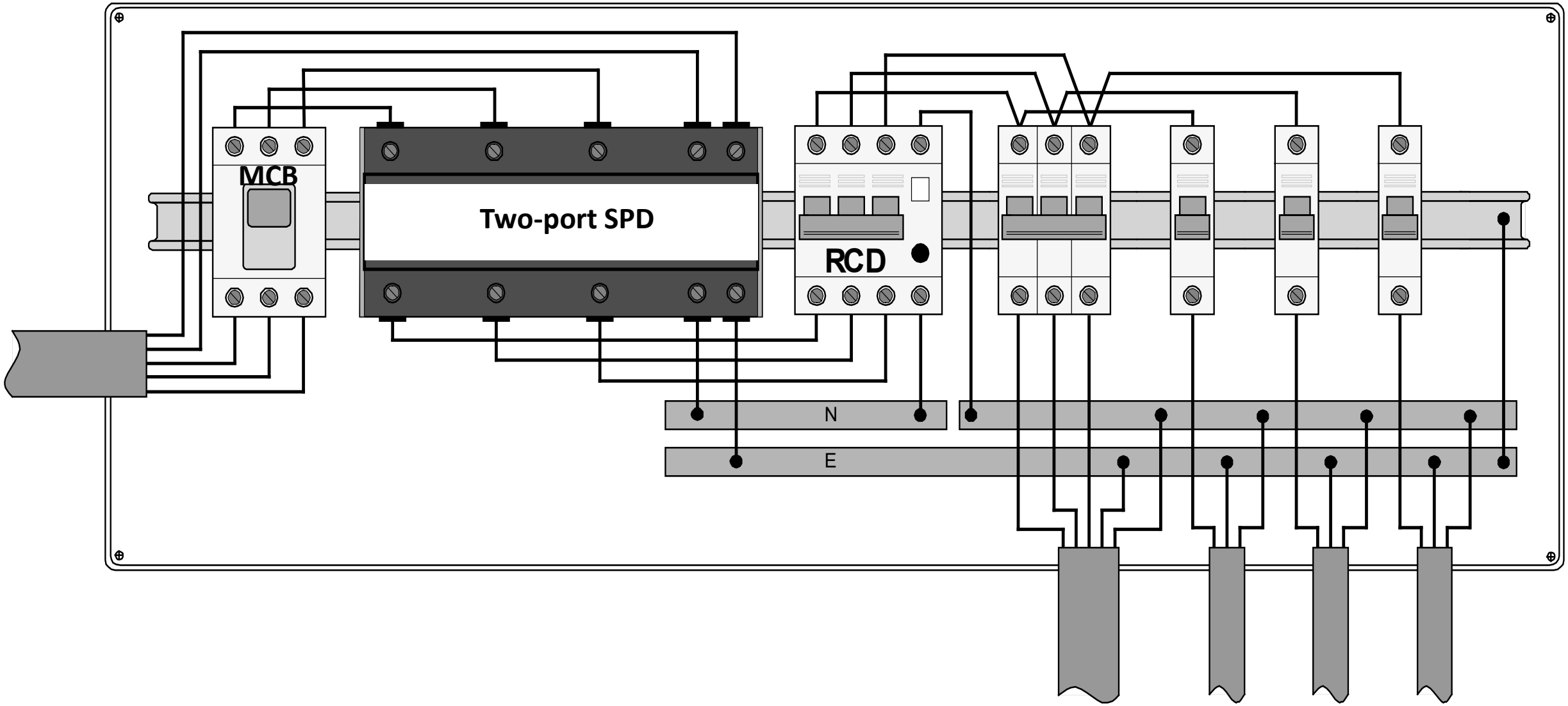
Two-Port SPD Installation



Private and Confidential

SPD Overcurrent Protection (IEC 61643-06)

SPD Over Current Protection

OCPD = Over Current Protection Device

- SPD draws **negligible AC current**
- SPD passes **high surge current**
- **OCPD must:**
  - Prevent catastrophic SPD failure
  - Pass the surge current, I_{max} or I_n
  - Coordinate with upstream OCPD

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Why OCPD?

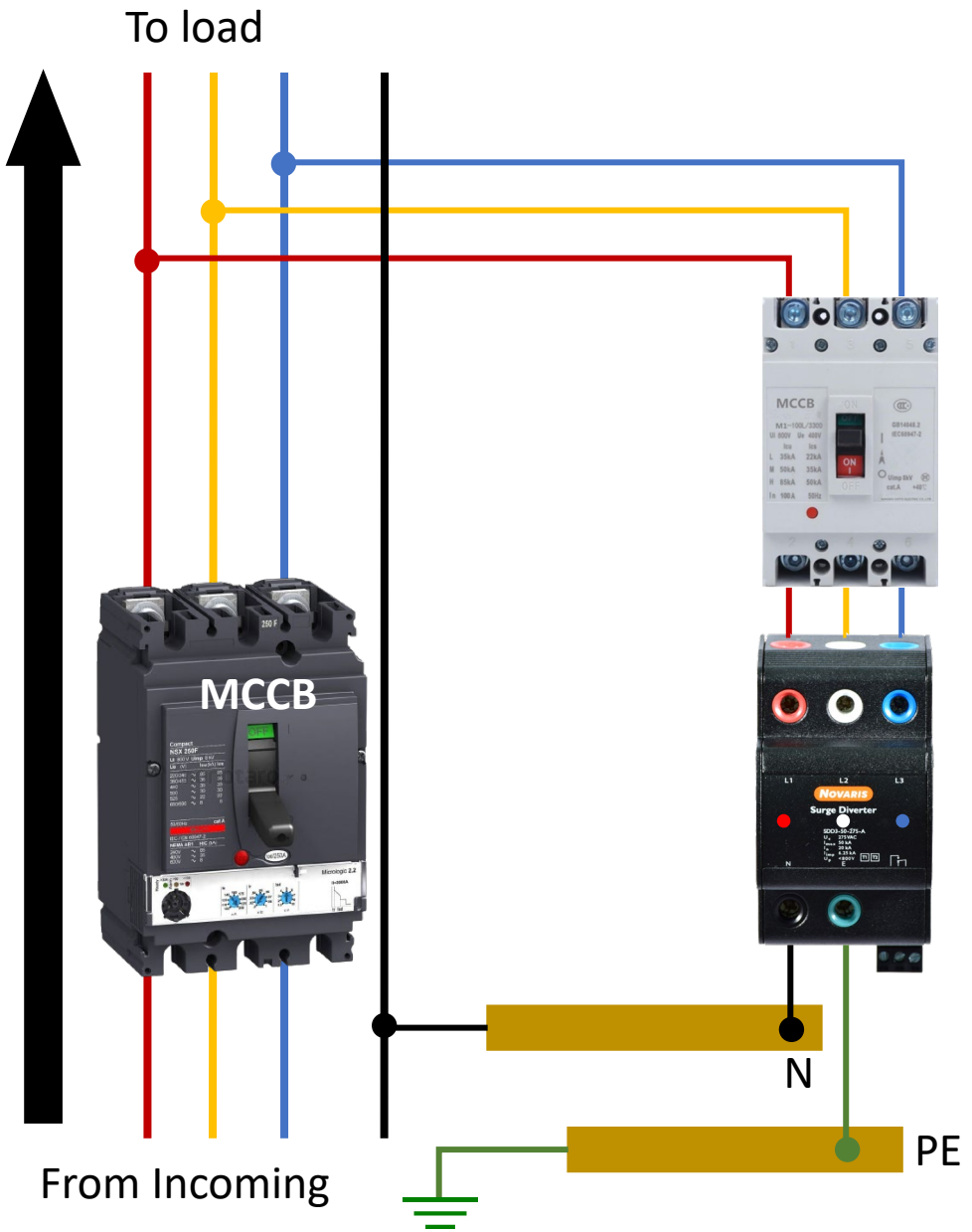
1. Maintenance / Isolation
2. Coordination with SPD
3. Protection from overheating due to 50Hz AC short circuit

Private and Confidential

Maintenance / Isolation

Normal Condition

Normal AC current (50Hz), full load of switchboard



OCPD: MCCB / MCB / Fuse

No current flow

SPD

Under normal conditions, there is no AC current (50Hz) flowing through the SPD

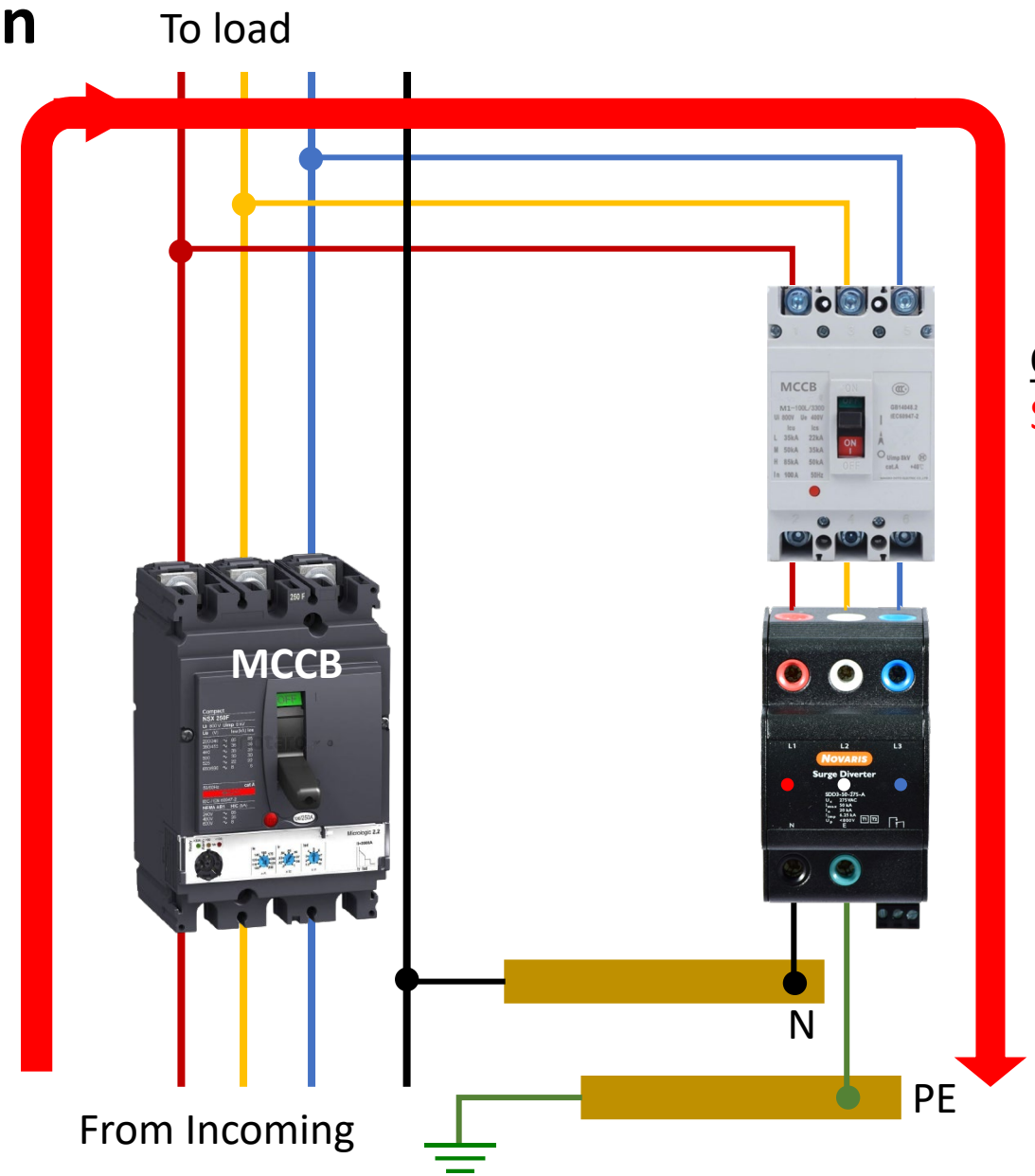
Private and Confidential

Maintenance / Isolation

Surge Condition

High frequency surge current

~200kHz
Surge lasts only about 30µs



OCPD: MCCB / MCB / Fuse
Surge current flow

SPD
Under surge conditions, high frequency current only flows for a few µs

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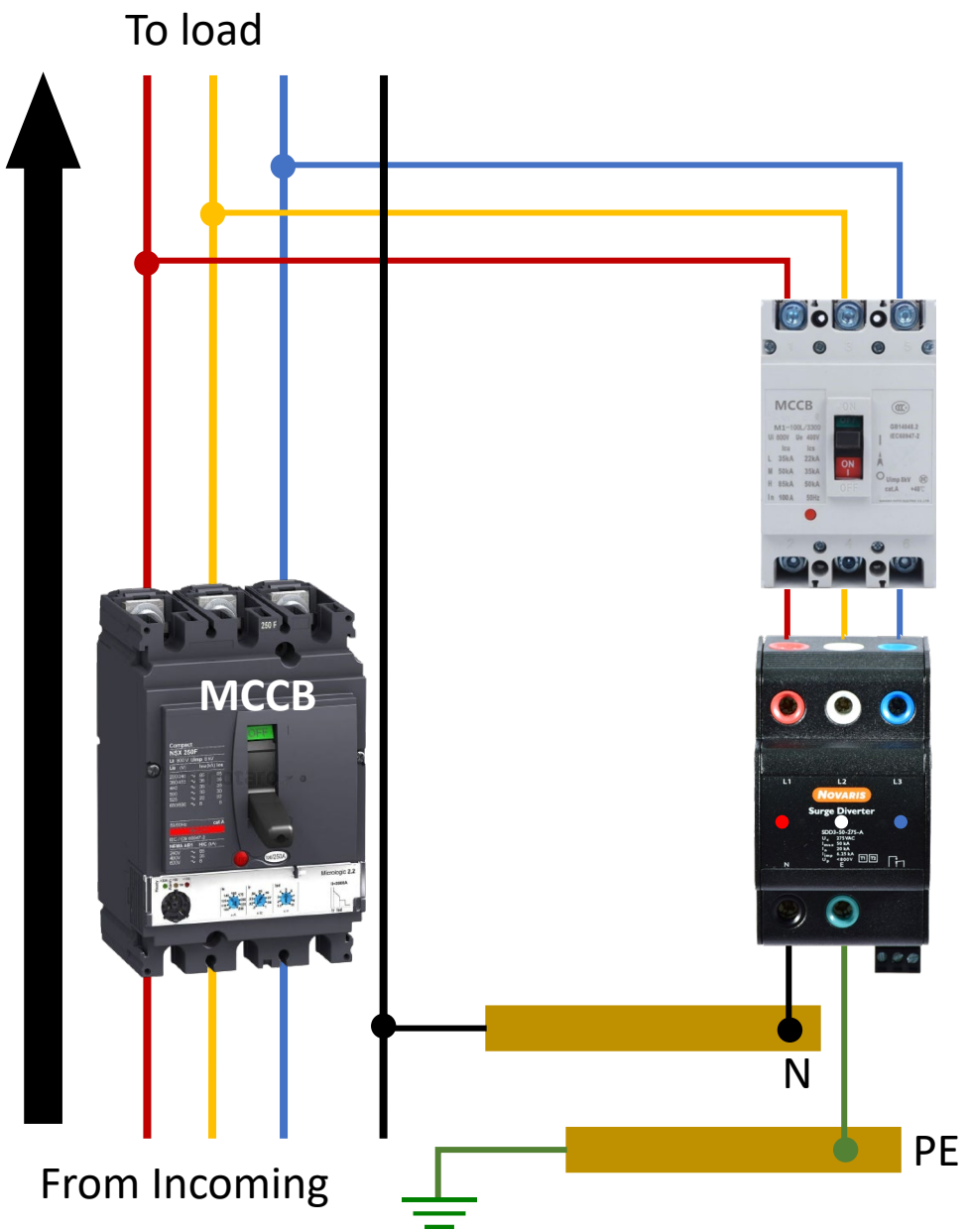
Maintenance / Isolation

After surge

Return to usual state
Normal AC current (50Hz), full load of switchboard



OCPD: MCCB / MCB / Fuse
No current flow

SPD
After surge diverted, surge current no longer flows through SPD

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SCB AS OCPD – SPD DISCONNECTOR

- High surge current rating
- 80kA 8/20µs
- 25kA 10/350µs
- AC trip current <4A
- Easy to install
- Wiring 6-10 sqmm

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Fault Current Comparison

Fault Current at Transformer : 50kA

- **125A HRC fuse**
- Resistance = 0.48 milliohms
- Fault current at fuse = **45.3kA**

- **SCB – SPD Disconnector**
- Resistance = 17.3 ohms + 450uH
- Fault current at SCB = **13.3A**

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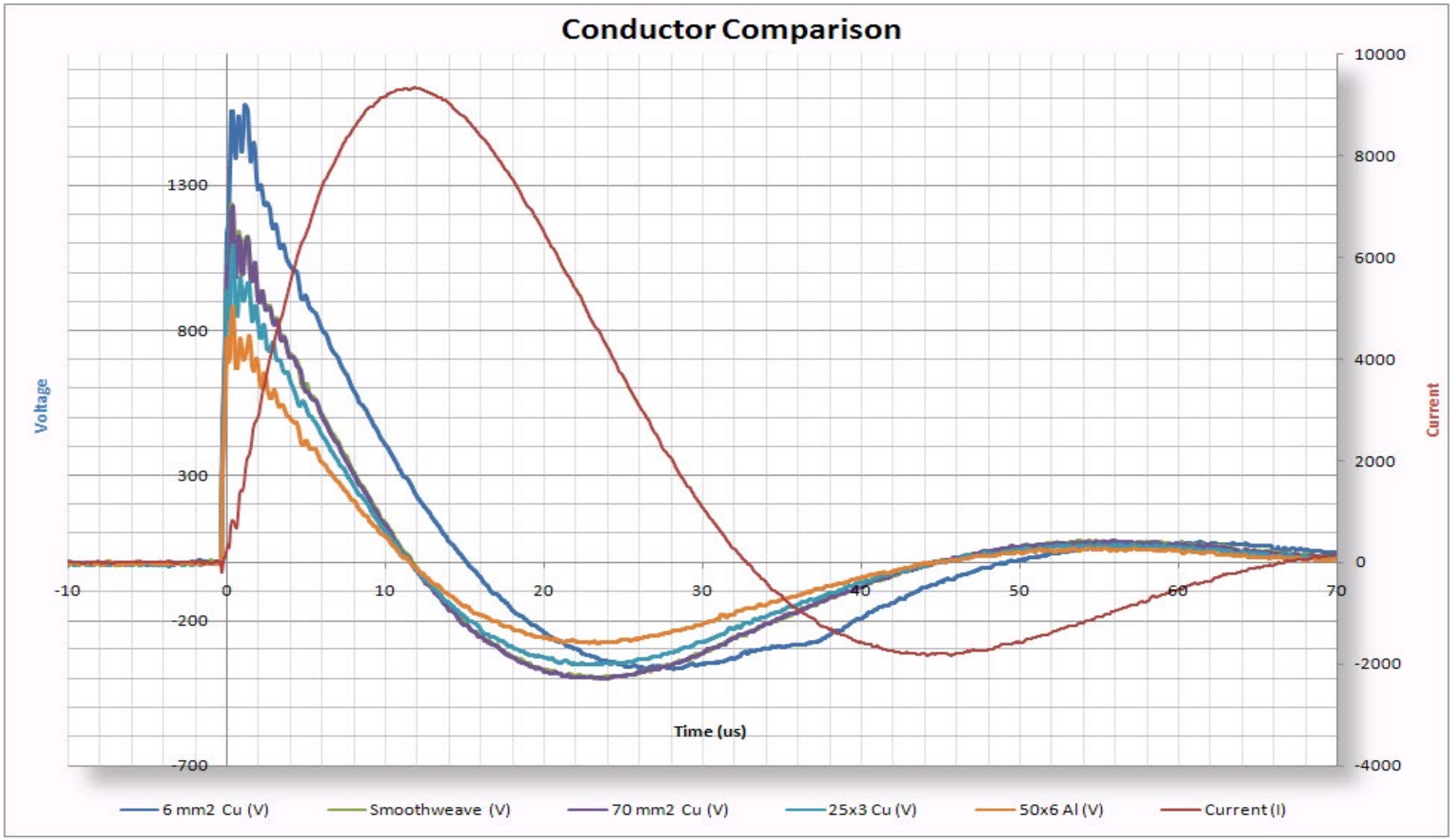
Impulse voltage across an inductor – 1m cable comparison – V=LxdI/dt



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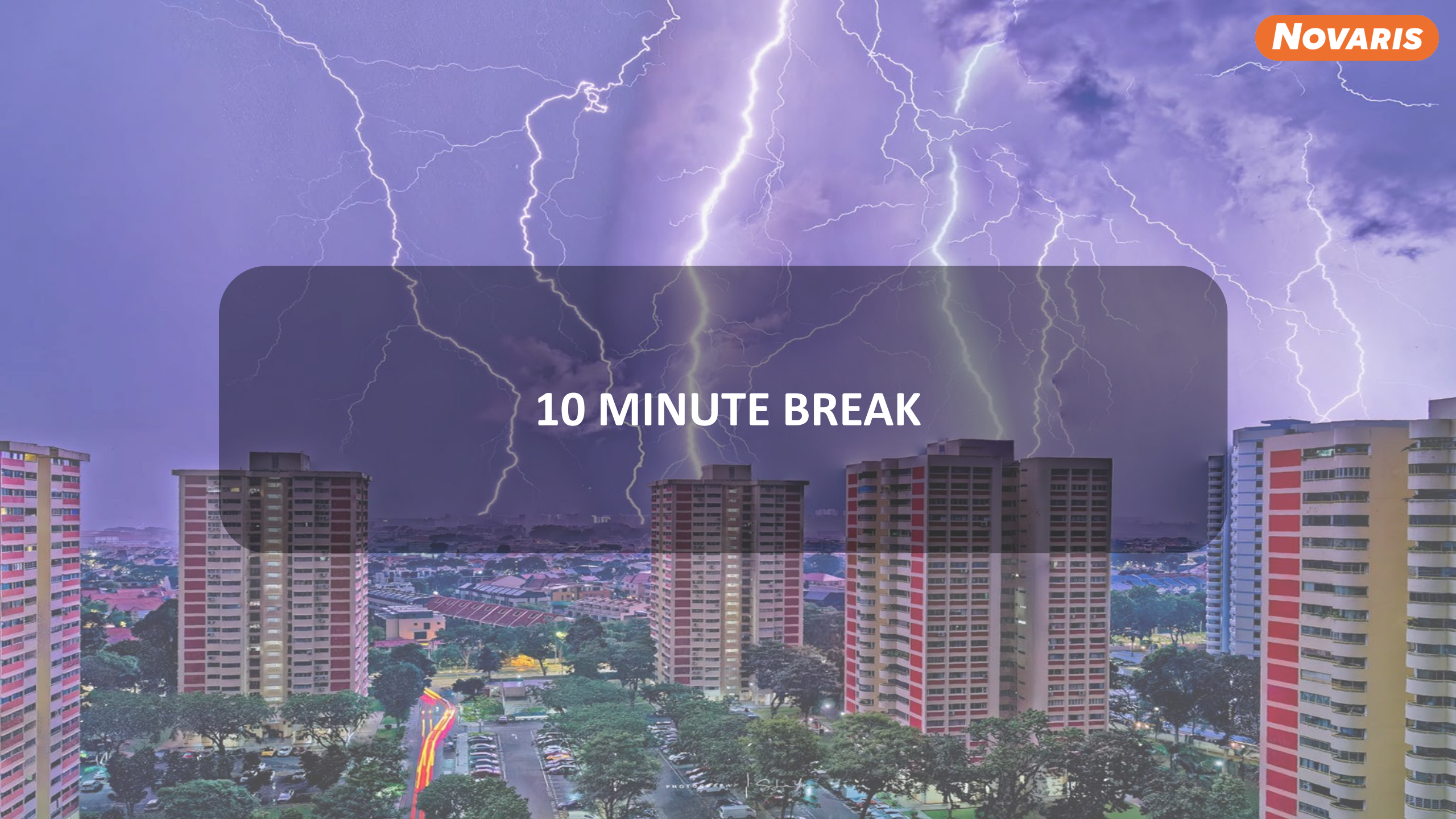
NOVARIS
10 MINUTE BREAK

Temporary Overvoltage (TOV)

Why OCPD?

1. Maintenance / Isolation
2. Coordination with SPD
3. Protection from overheating due to 50Hz AC short circuit - TOV

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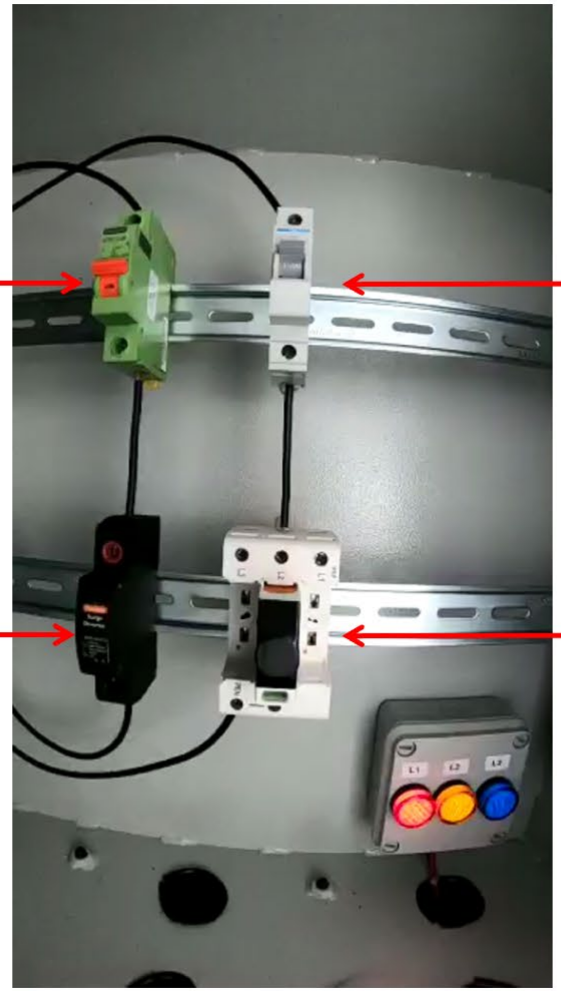
Simulation of TOV Condition in SPD

400VAC applied between L-N



- SPD1 with electronic LED and SCB
- SPD2 with mechanical flag and MCB

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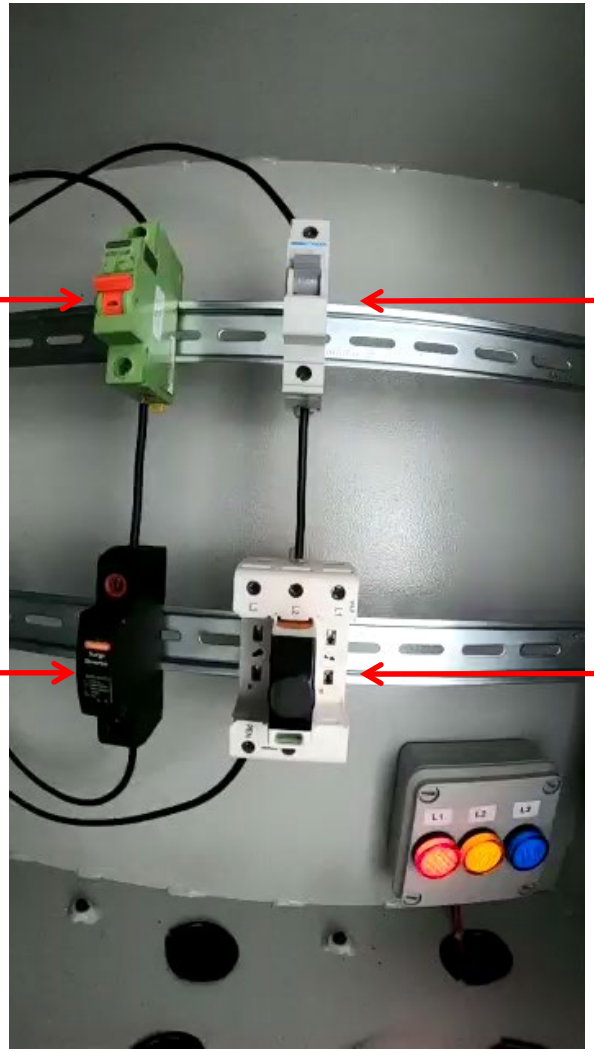
Simulation of TOV Condition in SPD

400VAC applied between L-N



- SCB trips, SPD1 safe
- SPD2 explodes, MCB trips
- Time taken < 300ms

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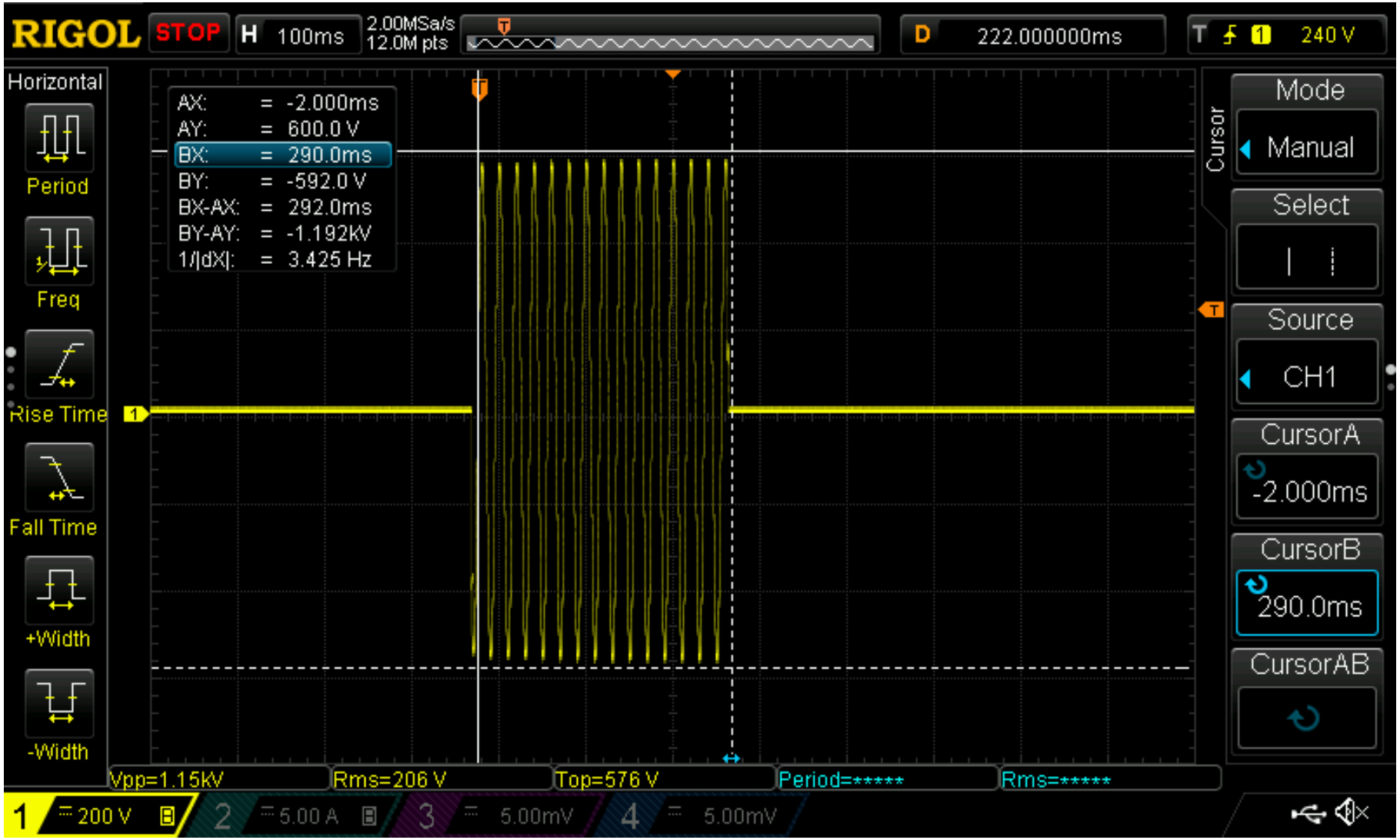
Simulation of TOV Condition in SPD



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Protection from overheating due to 50Hz AC short circuit

WHY is TOV an Issue?

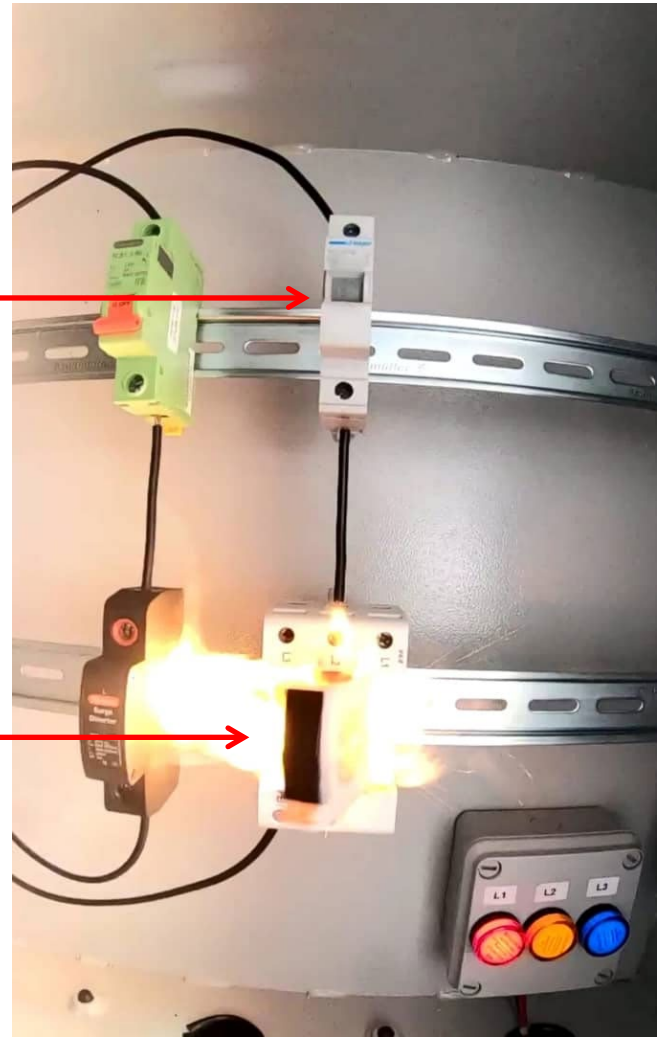
Temporary Over Voltage - TOV, can be caused by:

- Phase to Earth Fault
- Phase to Neutral Fault
- Broken Neutral
- Instability and Fluctuation in Power Grid

20A MCB couldn't trip to prevent this catastrophic event. Just imagine a 100A breaker!

SPD explodes when a TOV occur.

This was tested with 400VAC across the SPD.



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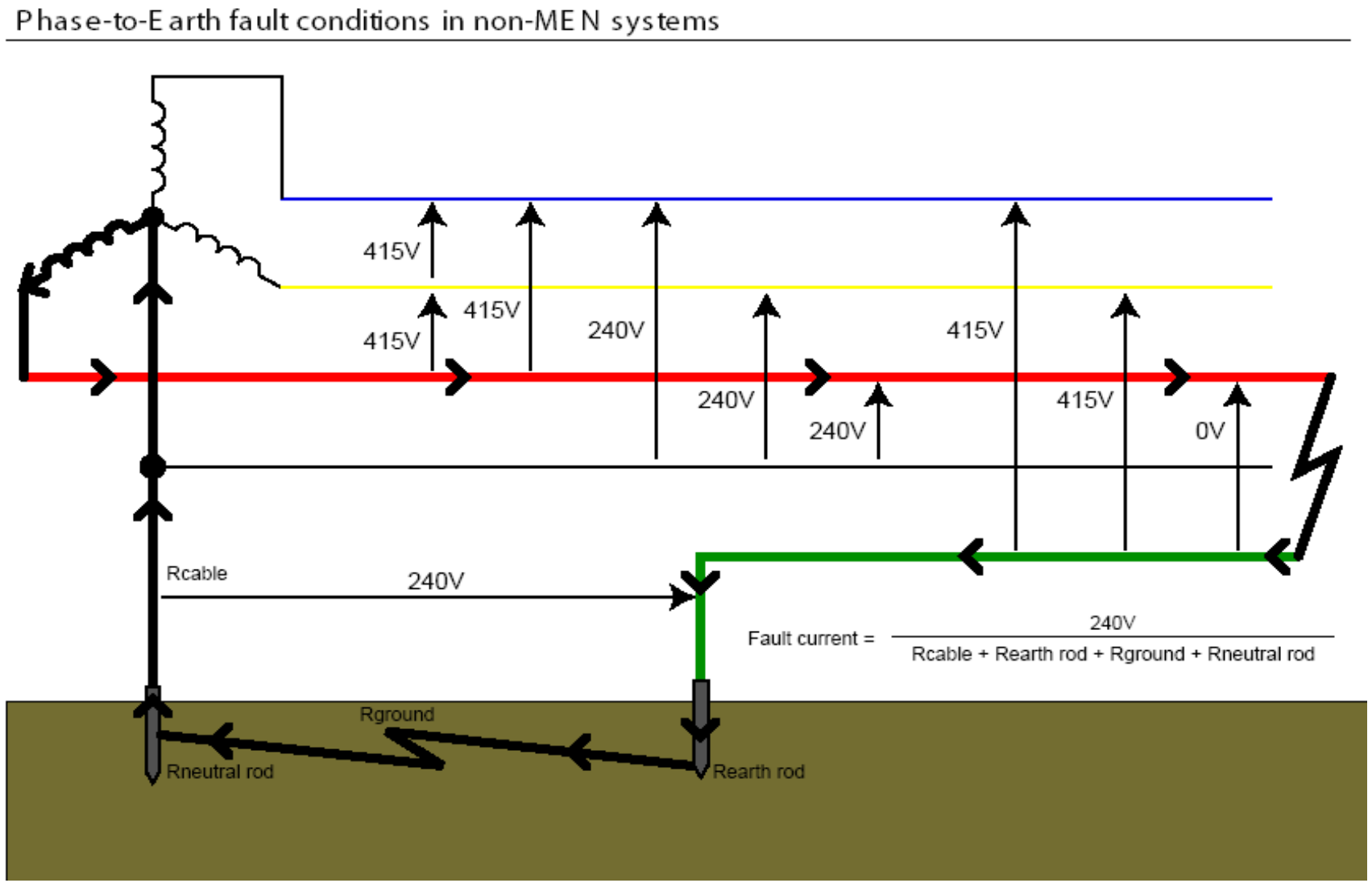
Power system fault causes TOV



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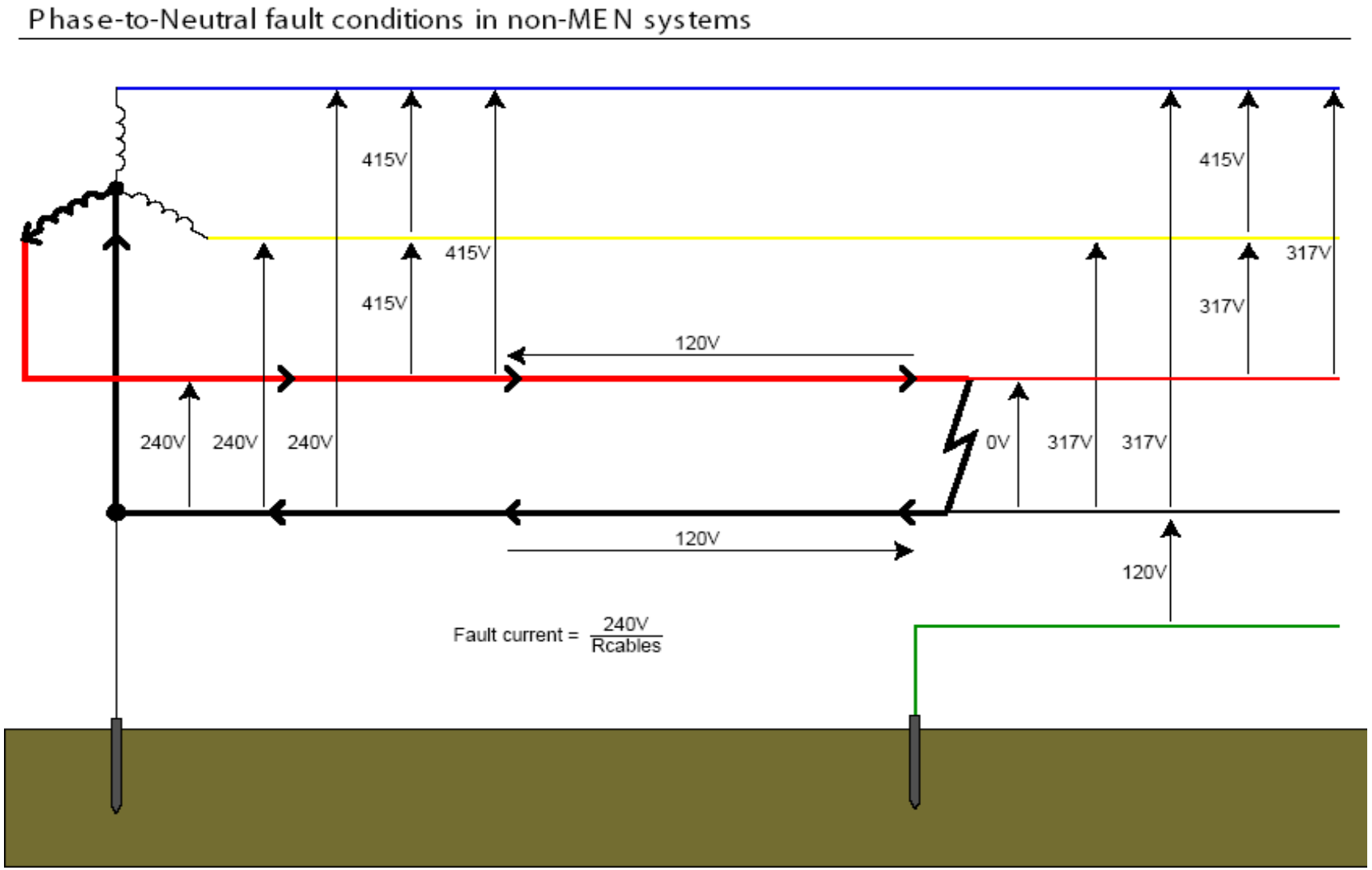
Power system fault causes TOV



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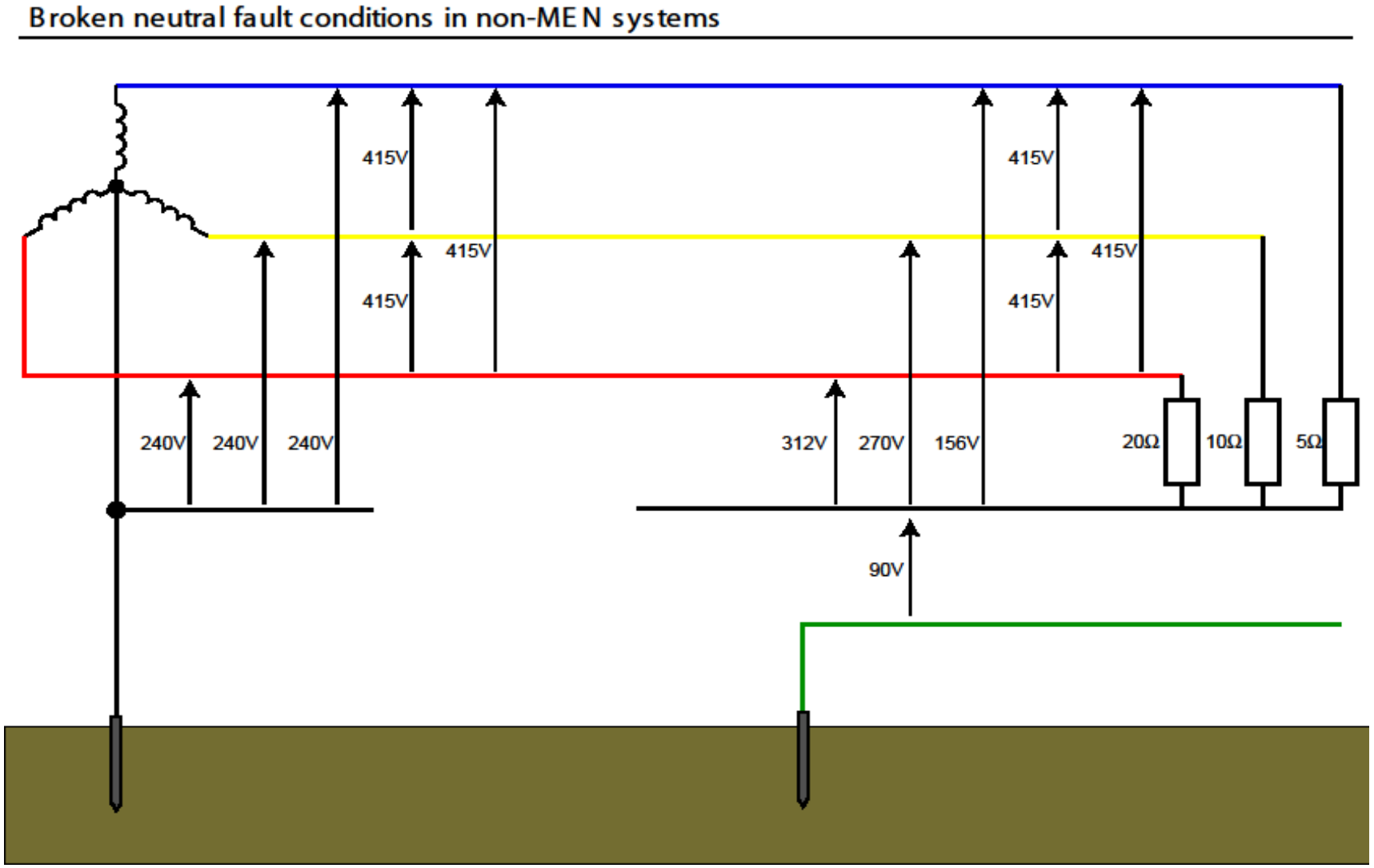
Power system fault causes TOV



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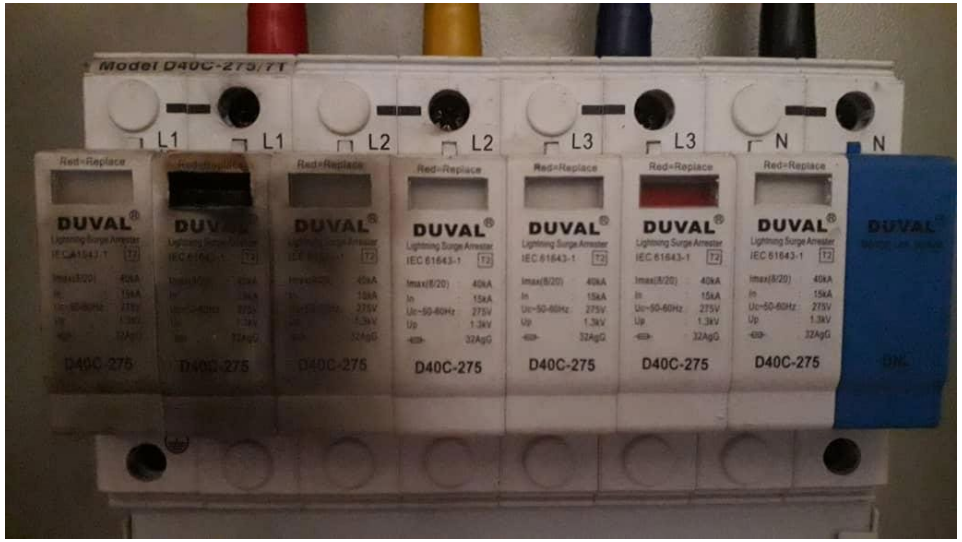
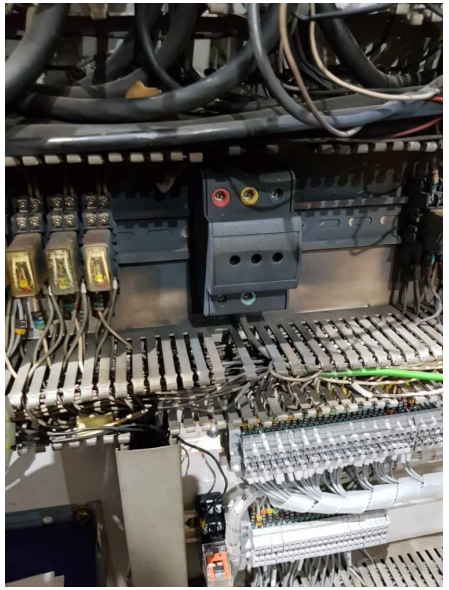
Why is TOV an issue? – Can cause SPD to explode under prolonged exposure





MOV Failure Mode

- Short Circuit
- Thermal cut-out does not trip

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Temporary Overvoltage

Nominal voltage of the system according to IEC 60664-1		Examples of U_c based on values given in IEC 60364-5-534			
Three-phase, four-wire system, neutral earthed	Three-phase, three-wire or four-wire system, unearthed	U_c min. for SPD installed between phase and PE or PEN in the case of TN systems[a] or between phase and neutral in the case of TT systems[a]	U_c min. for SPD installed between phase and earth or neutral and earth in the case of TT systems[a]	U_c min. for SPD installed between phase and earth or neutral and earth in case of IT systems	U_c min. for SPD installed between phase to phase in case of TT, TN or IT systems
TT and TN systems	IT system	Case where voltage regulation is equal to 10 %	Case where a value of $1{,}5 \times U_0$ has been used	Case where a value of $\sqrt{3} \times U_0$ has been used	Case where voltage regulation is equal to 10 %
V	V	V	V	V	V
120/208		132	180		229
127/220	220	140	191	220	242
	230, 240			240	264
	260, 277, 347			347	382
220/380, 230/400	380,400	253	345	400	440
240/415, 260/440	415	286	390	415	484
277/480	440, 480	305	416	480	528

[a] Higher values may be needed under some conditions (for example, the loss of neutral in TT systems).

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Typical Wiring as per IEC 61643-12 for TT System

Typical Wiring Diagram of SPD 3+1 as recommended by IEC

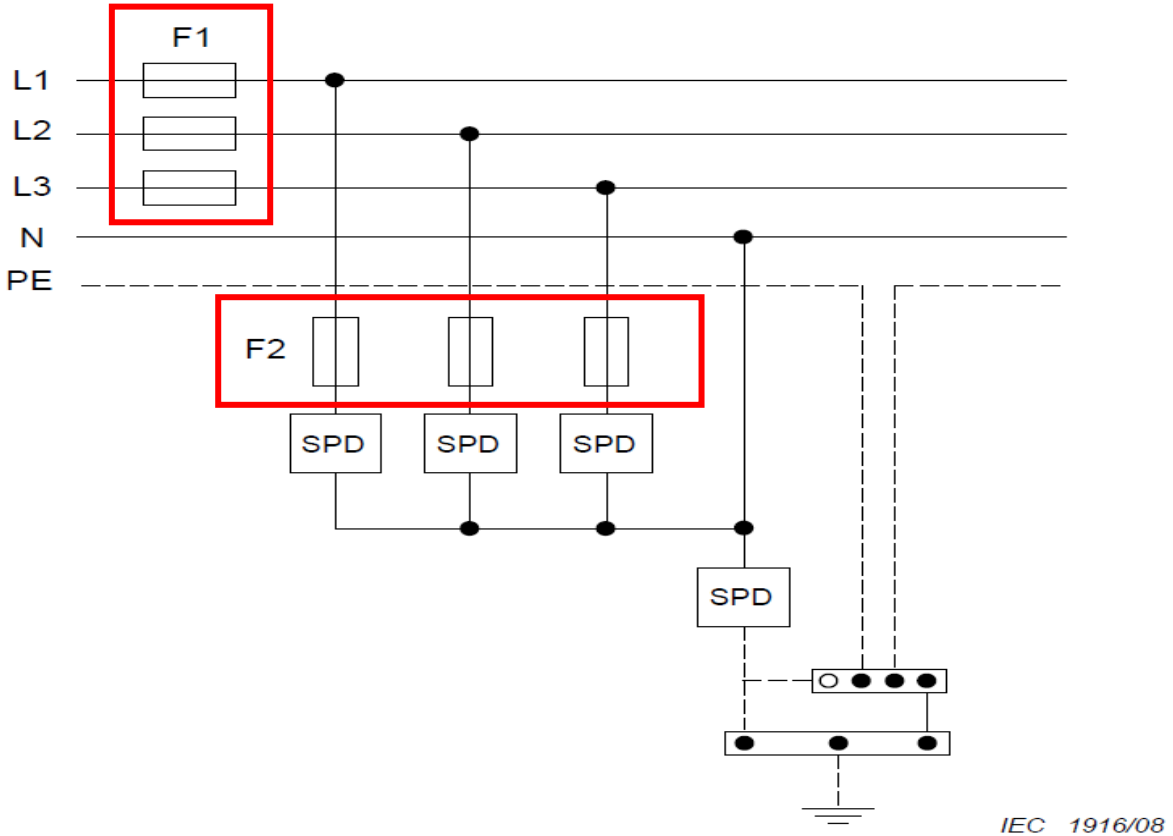

Figure 9 – Connection Type 2 (CT2)

Symbol:

- F1 – Incoming OCPD
- F2 – OCPD for SPD

Wiring Rules:

- F2 < F1
- F2 recommended by manufacturer
- F2 to be a suitable dedicated SPD disconnector

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Fuse Rating Table

From IEC 61643-12

Withstand capabilities of gG fuse-links towards operating and additional duty tests					
Rated current of fuse link (A)	Minimum prearcing I^2t (Table 113, IEC 60269-2))	Evaluated minimum Adiabatic I^2t (A^2s)	Safety coefficient (on the value of current)	Maximum I_n (kA) (8/20 µsec)	Maximum I_{imp} (kA) (10/350 µsec)
8	40	24		1,2	0,3
10	68	41		1,5	0,3
12	130	78		2,1	0,5
16	291	175		3,1	0,7
20	640	384		4,6	1,0
25	1 210	726		6,4	1,4
32	2 500	1 750		9,9	2,2
40	4 000	2 800		12,5	2,8
50	5 750	4 025		15	3,4
63	9 000	6 300		19	4,2
80	13 700	10 960	0,85	25	5,6
100	21 200	19 080		33	7,3
125	36 000	32 400		42	9,6
160	64 000	57 600		57	13
200	104 000	93 600		72	16
224	139 000	125 100		83	19
250	185 000	166 500		96	22
315	302 000	271 800		123	28
400	557 000	445 600		157	35
500	900 000	720 000		200	45
630	1 600 000	1 280 000		267	60

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MCB as OCPD

TABLE 1 I_{MW} OF H-C MCB FOR 10/350µS SURGE

Rating current (A)	Coordinate with Type I SPD			
	$\mathbf{I_{MW}}$ for 10/350µs		Preferred values	
	I_{peak} (kA)	Q (As)	I_{peak} (kA)	Q (As)
50	1.051	0.428	1	0.5
63	2.059	0.829	2	1
100	3.088	1.284	2	1
125	4.114	1.740	2	1

TABLE 2 I_{MW} AND I_{15} OF H-C MCBS FOR 8/20µS

Rating current (A)	Coordinate with Type II SPD		
	$\mathbf{I_{MW}}$ for 8/20µs (kA)	$\mathbf{I_{15}}$ (kA)	Preferred values for I_n (kA)
10	14.224	10.644	10
16	22.176	14.130	10
20	22.906	20.306	10
25	30.142	24.172	15
40	38.041	25.111	15
50	33.144	25.062	15
63	34.716	25.138	15
100	59.912	35.327	30
125	59.906	40.717	30

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MCB as OCPD

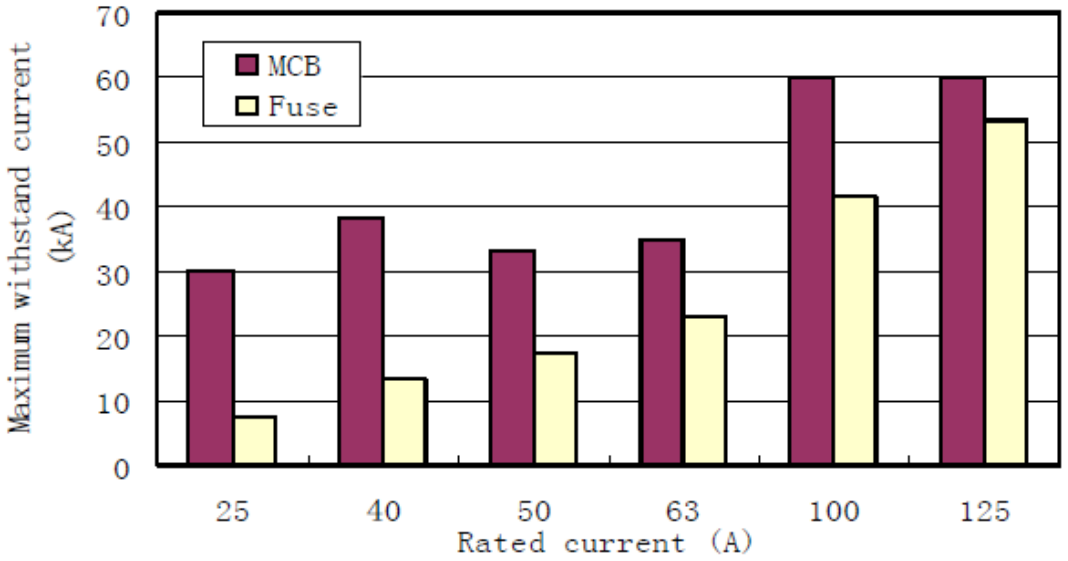

Figure 2. I_{MW} of MCBs and single shot withstand current of fuses

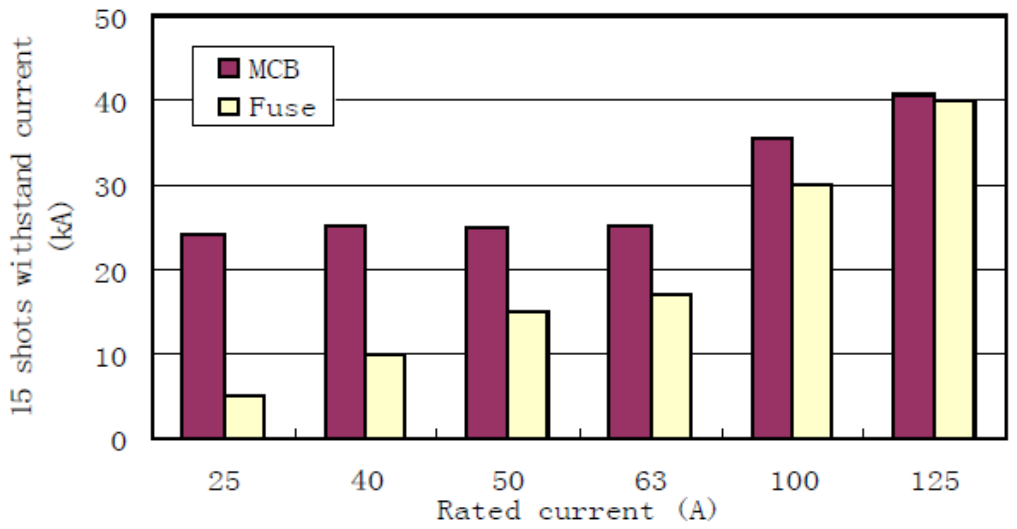

Figure 3. I_{15} of MCBs and fuses

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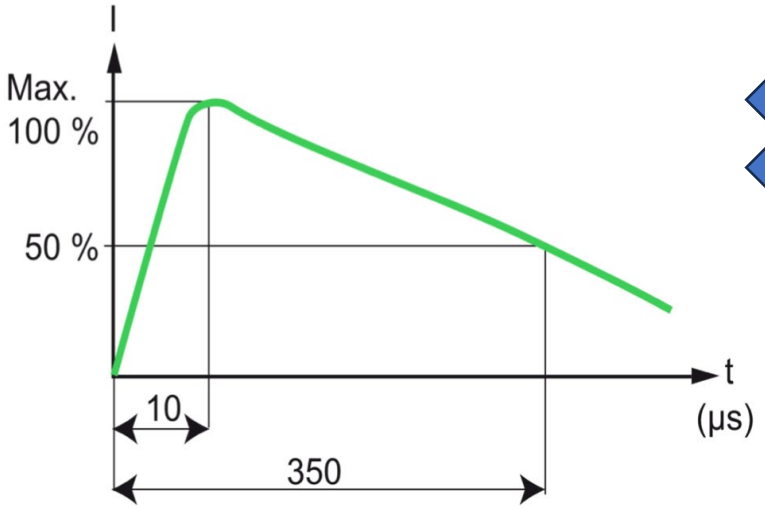
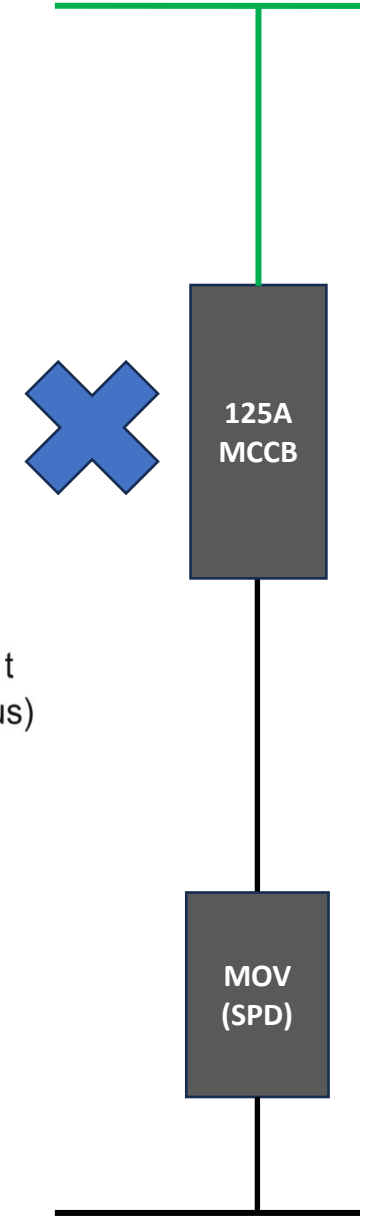
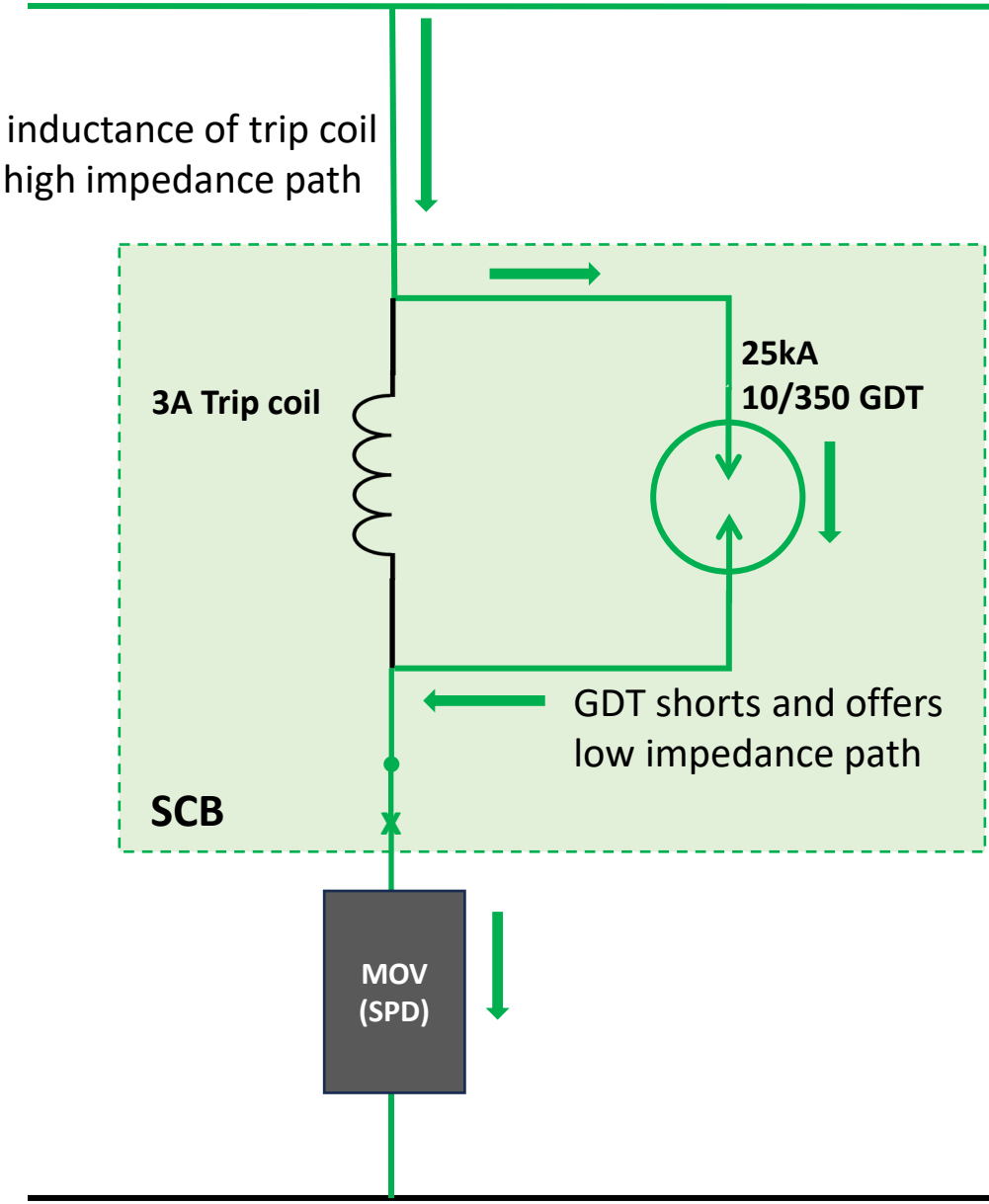
Surge Circuit Breakers (SCB)

During 10/350us Surge Impulse





VS



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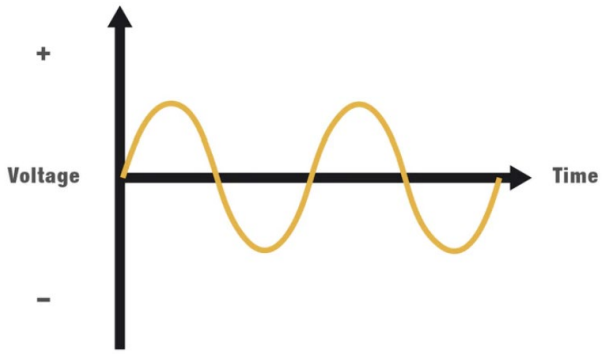
Surge Circuit Breakers (SCB)

MCCB failed trip and
MOV (SPD) was damaged

During AC Temporary Voltage



125A
MCCB

MOV
(SPD)

VS

Line

3A will trip the coil and protect
the MOV (SPD) from exposure

3A Trip coil

25kA
10/350 GDT

GDT not triggered by
50Hz AC

SCB

MOV
(SPD)

Neutral

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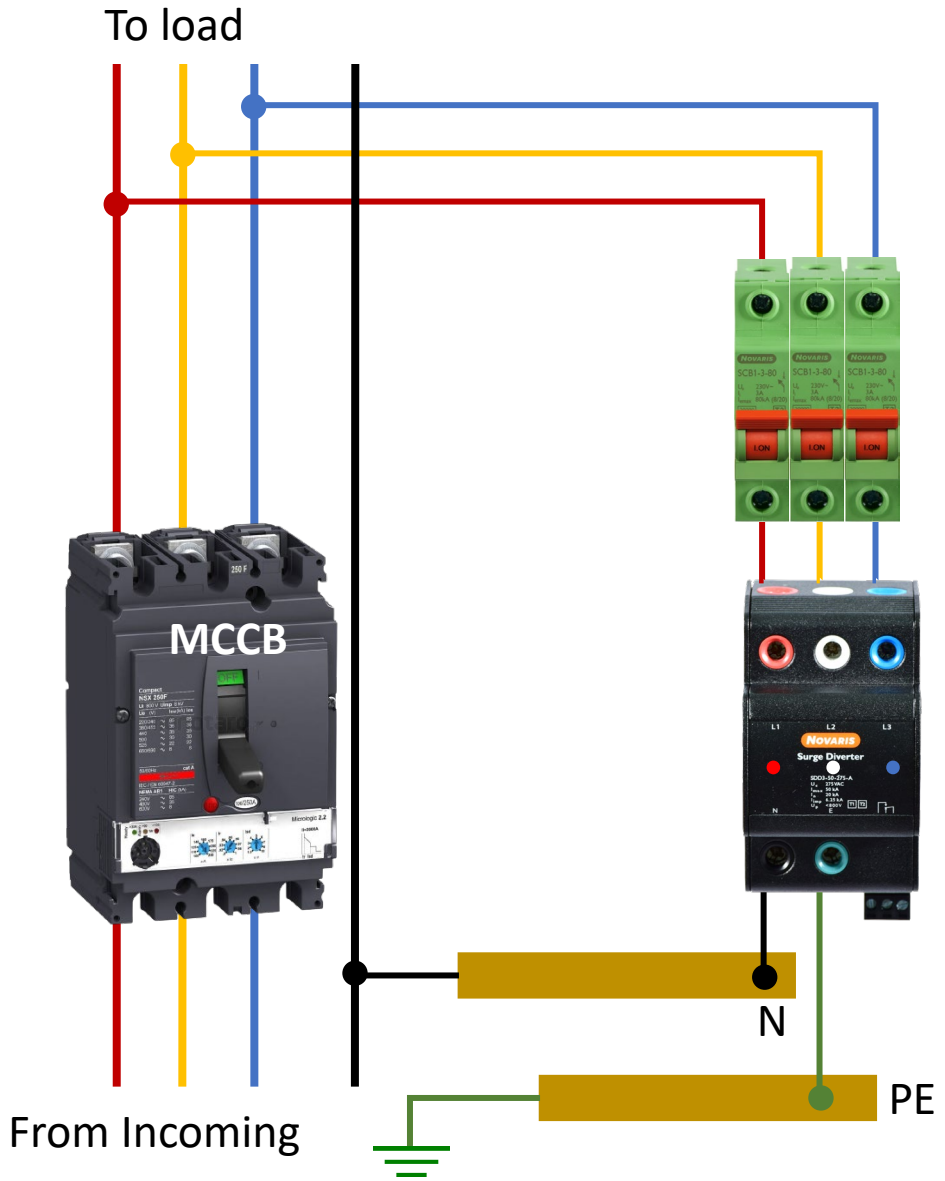
SPD Specific Disconnectors – Surge Circuit Breakers (SCB)

Recommendation →



SCB:

AC Trip rating:

- SCB rated at 3A 50/60Hz AC and trips at 3A protecting SPD against TOV

Surge rating:

- SCB1-3-80 can pass through 80kA 8/20µs
- SCB1-3-25 can pass through 25kA 10/350µs

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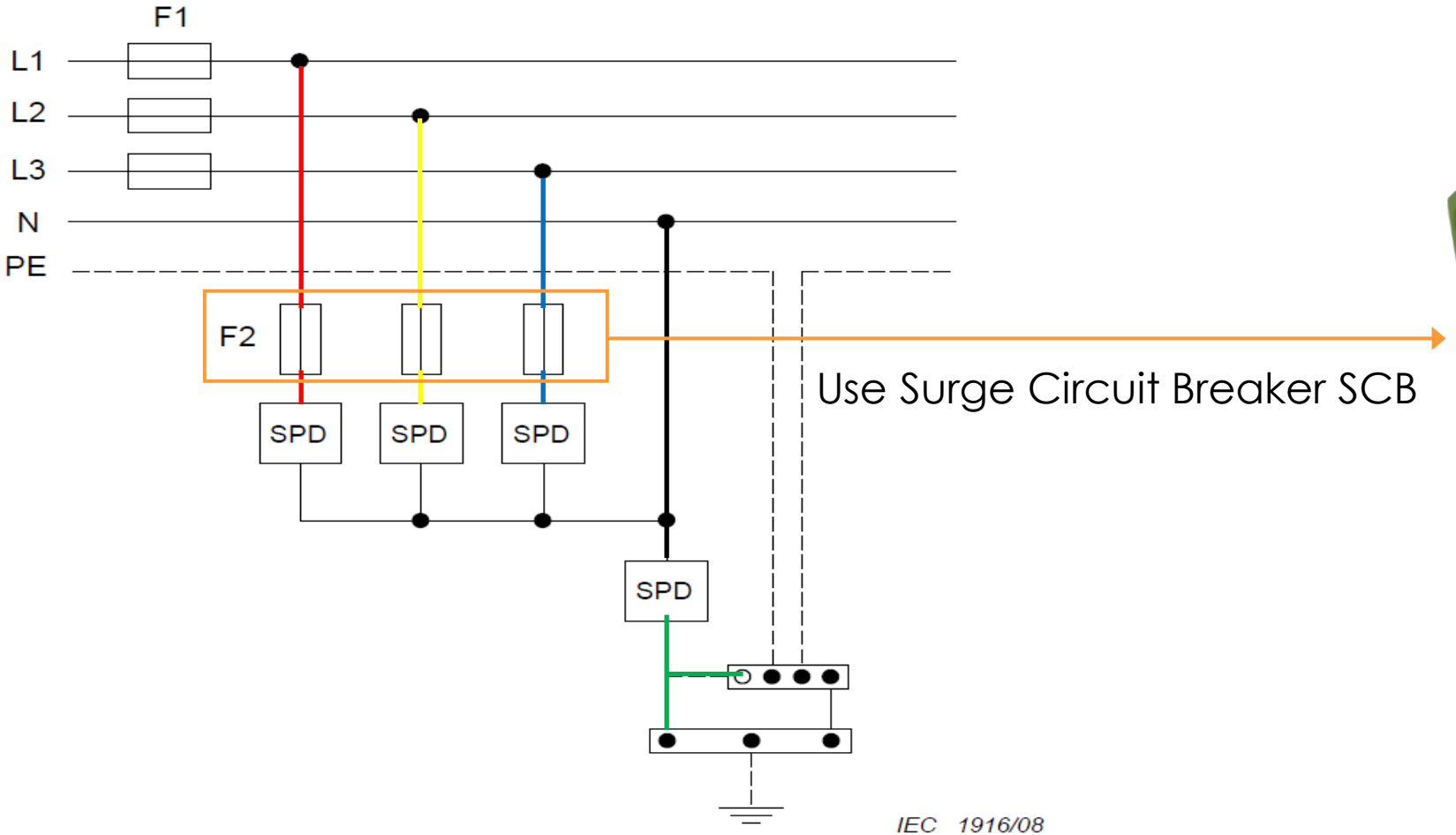
SPD Specific Disconnectors – Surge Circuit Breakers (SCB)



Use Surge Circuit Breaker SCB

SCB1-3-80
For 8/20
Type 2

SCB1-3-25
For 10/350
Type 1

Figure 9 – Connection Type 2 (CT2)

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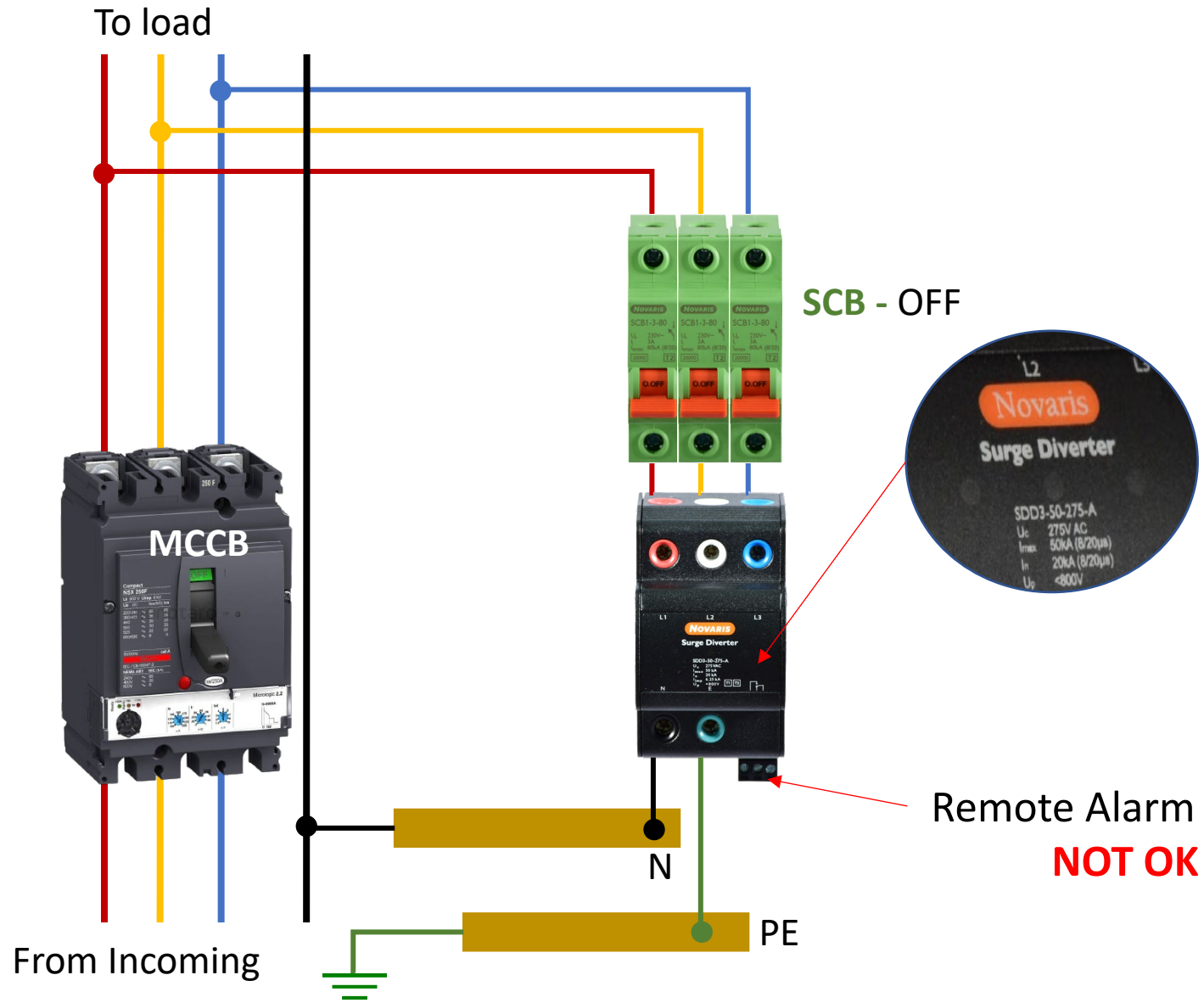
Coordination of SCB with SPD

Before Power Up



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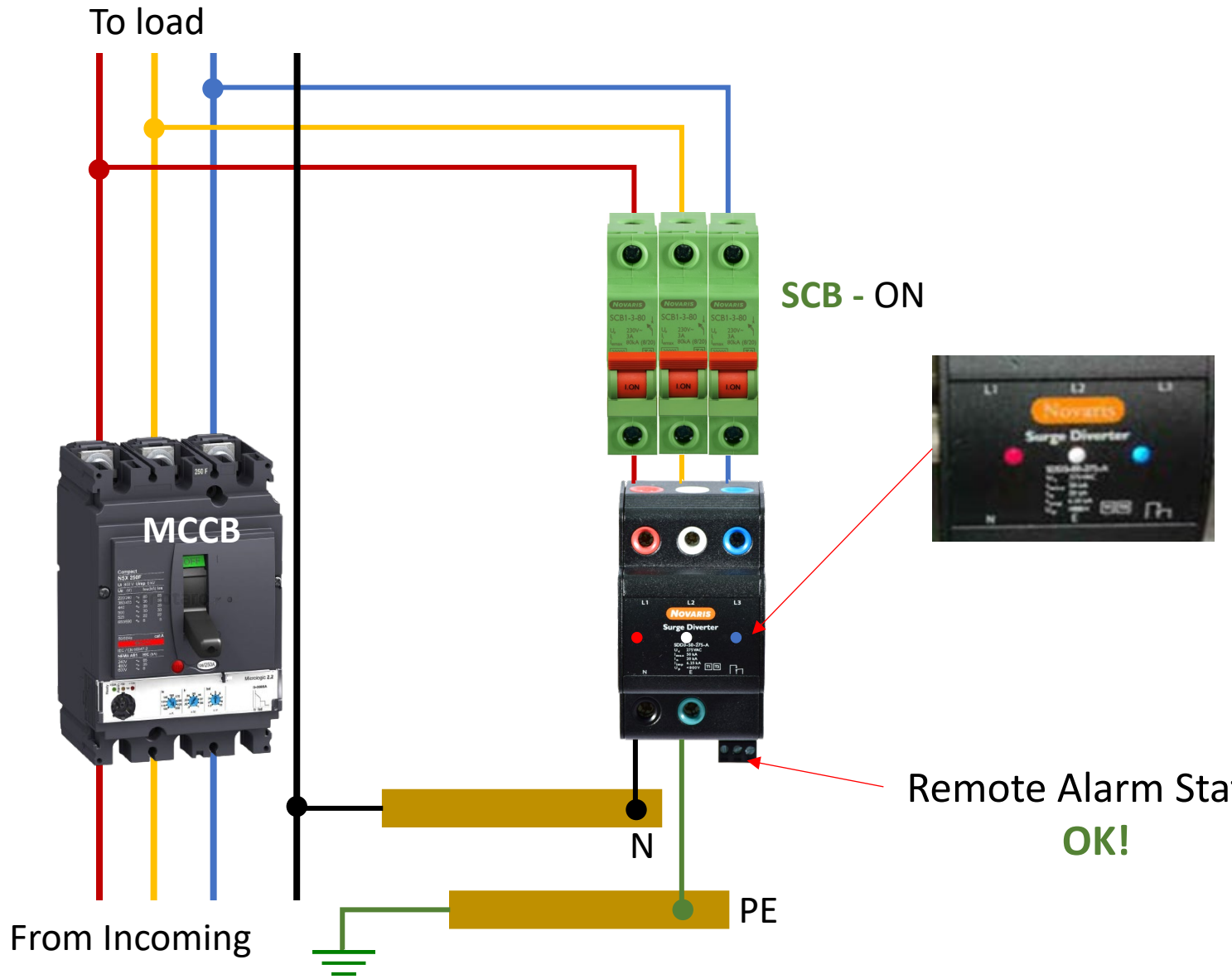
Coordination of SCB with SPD

After Power Up
(Normal Operation)



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Surge Circuit Breaker vs Fuse / MCB for SPD

	SCB	125A Fuse	125A MCB
TOV protection	Full protection	Almost no protection	Almost no protection
Surge ratings	Rated at 80kA 8/20 & 25kA 10/350	Rated at 40kA (8/20) & 10kA (10/350)	Rated at 60kA (8/20) & 4kA 10/350
AC trip rating	3A, 50 Hz	125A, 50Hz	125A, 50Hz
Cable size	Same and **smaller cable sizes as SPD (4 or 6sq.mm)**	Big cables, based on the rating of the fuse	Big cables, based on the rating of the MCB

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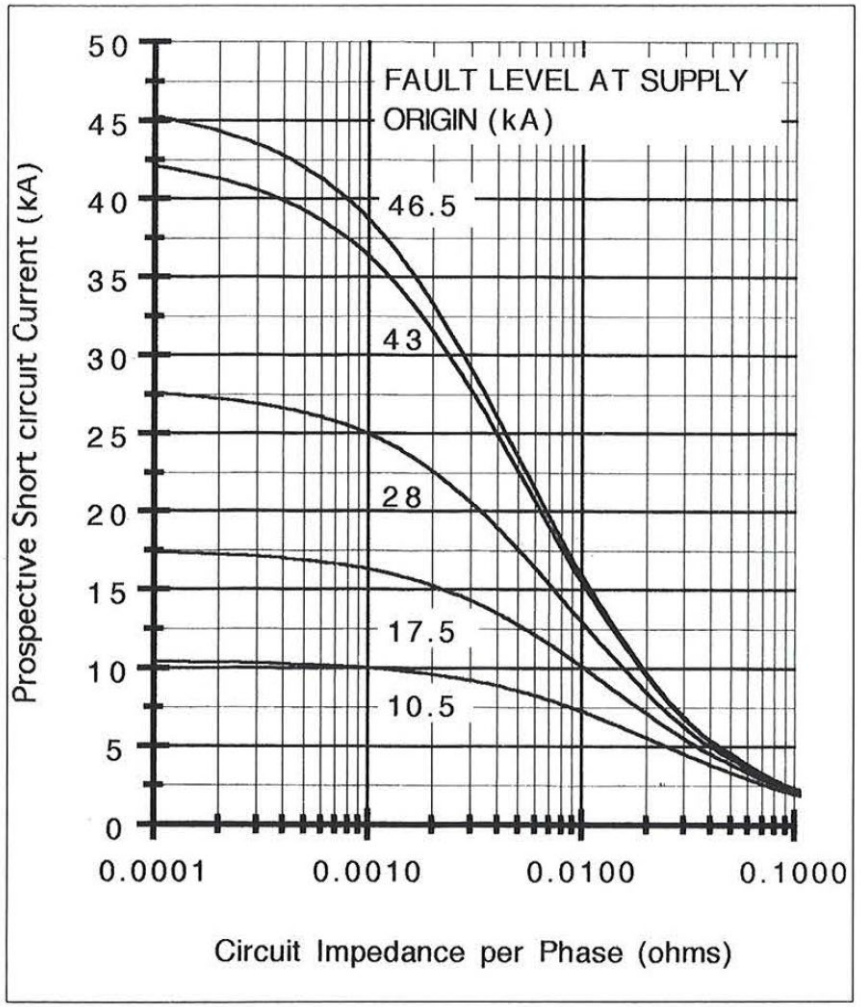
Short Circuit fault Withstand Capability



Transformer kVA	X Ω	R Ω	Z Ω	Impedance %	Fault prospective kA
250	0.0120	0.0200	0.0230	3.3	10.5
500	0.0052	0.0120	0.0137	4.0	17.5
1000	0.0026	0.0081	0.0086	5.0	28.0
1500	0.0015	0.0053	0.0056	5.0	43.0
2000	0.0012	0.0050	0.0052	6.0	46.5

Fault level at the transformer terminals

≠

Actual fault level at the switchboard

There is significant reduction due to reducing factors:

- Source Impedance at the Transformer terminals
- Impedance of connecting cables / busbars

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Fault Current - I_{SCCR}

- Assume a Switchboard fault rating of 50kA (50Hz AC)
- Not to be confused with I_{imp} or I_{max} rating

Loop Impedance = Source impedance of supply transformer + connections + fault resistance

- For 230V, and 50kA = 4.6 mΩ
- SPD connected with 1m of 6sqmm cable, conductor resistance = 3.23 mΩ

➢ **Fault current through SPD = 230V/(4.6 + 3.23mΩ) = 29.4 kA**

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Fault Current Comparison

Example: Fault Current at Transformer : 50kA

- **125A HRC fuse**
- Resistance = 0.48 milliohms
- Fault current at fuse = **45.3kA**

- **SCB – SPD Disconnector**
- Resistance = 17.3 ohms + 450uH
- Fault current at SCB = **13.3A**

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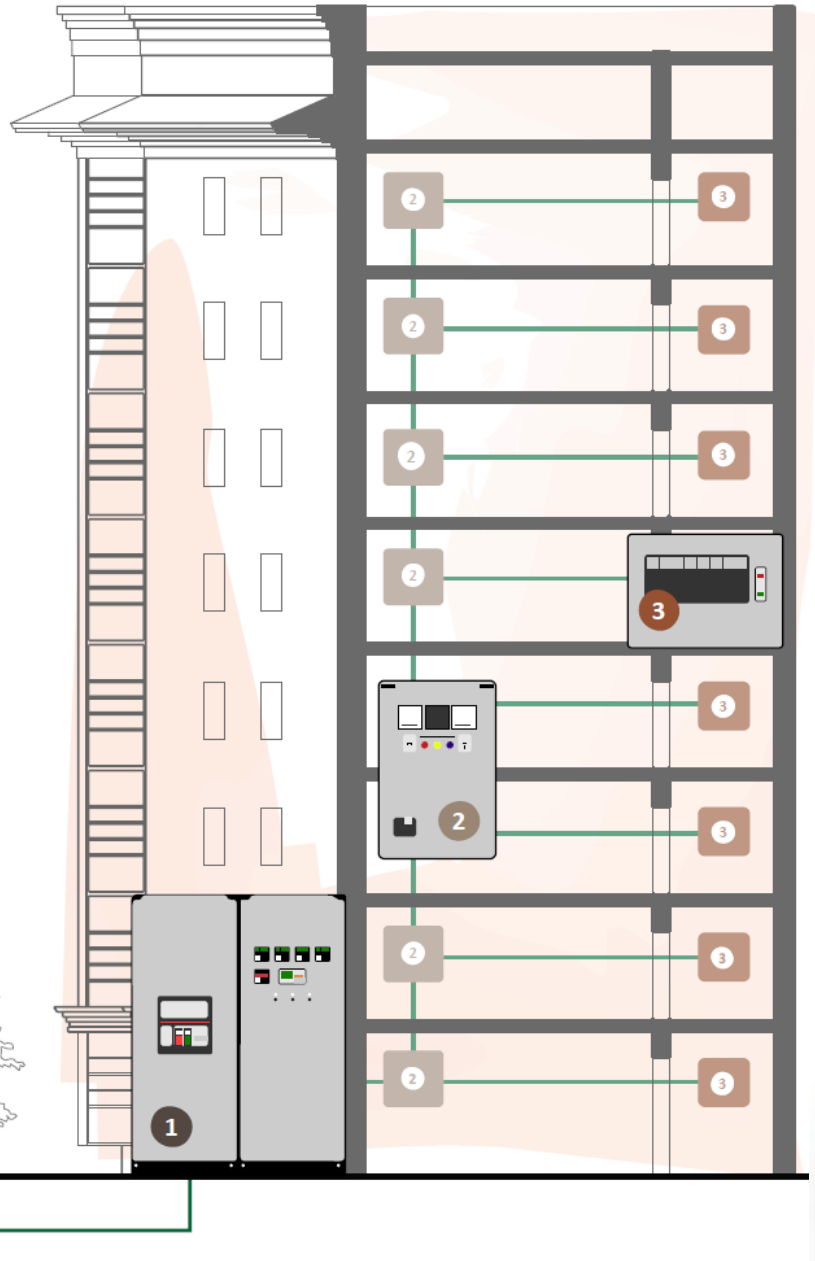
Surge Protection for Switchboards



3 Distribution Board

2 Sub Switchboard

1 Main Switchboard

Distribution Board 3

- NXP1-40-320-N
  Imax 40kA, Class 2
- SCB1-3-80

Sub Switchboard 2

- SDD3-100-275
  Imax 100kA, Class 1+2
- SCB1-3-80 x3 nos

Main Switchboard 1

- SDN3-200-275
  Imax 200kA, Class 1+2
- SCB1-3-25 x3 nos

Specification Examples

Tender Specification – General SPD requirements

- Compliant to **IEC 61643-11,12**
- SPD must have **remote and local indicator**
- **Fuse or MCB shall be based on SPD manufacturer recommendation**
- **Type I SPD with 25kA I_{imp}** for MSB
- **Type II SPD with 40kA I_{max}** for DB

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Example of SPD Specification for Main switchboard

For Class I surge protection device at the main low tension switchboard shall spark gap technology, the SPD shall be able to perform under a standard test wave of 25kA 10/350µs current impulse Iimp (per module). The voltage protection level Up shall be <2.5KV. The follow current interrupting rating Ifi of the SPD shall be 50KA or > than the Isc (Prospective Short Circuit Current) at the point of SPD installation. End of live disconnector (fuse or MCB) shall be installed with manufacturer recommendation.

315A HRC fuse + cables are required

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Withstand capabilities of gG fuse-links towards operating and additional duty tests					
Rated current of fuse link (A)	Minimum prearcing I^2t (Table 113, IEC 60269-2))	Evaluated minimum Adiabatic I^2t (A^2s)	Safety coefficient (on the value of current)	Maximum I_n (kA) (8/20 µsec)	Maximum I_{imp} (kA) (10/350 µsec)
8	40	24		1,2	0,3
10	68	41		1,5	0,3
12	130	78		2,1	0,5
16	291	175		3,1	0,7
20	640	384		4,6	1,0
25	1 210	726		6,4	1,4
32	2 500	1 750		9,9	2,2
40	4 000	2 800		12,5	2,8
50	5 750	4 025		15	3,4
63	9 000	6 300		19	4,2
80	13 700	10 960	0,85	25	5,6
100	21 200	19 080		33	7,3
125	36 000	32 400		42	9,6
160	64 000	57 600		57	13
200	104 000	93 600		72	16
224	139 000	125 100		83	19
250	185 000	166 500		96	22
315	302 000	271 800		123	28
400	557 000	445 600		157	35
500	900 000	720 000		200	45
630	1 600 000	1 280 000		267	60

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Withstand Levels for LV

Table 1 – Rated impulse voltage for equipment energized directly from the low-voltage mains

Nominal voltage of the supply system [1] based on IEC 60038 [3]		Voltage line to neutral derived from nominal voltages a.c. or d.c. up to and including V	Rated impulse voltage [2]			
			Overvoltage category [4]			
Three phase	Single phase		I	II	III	IV
230/400 277/480 400/690 1 000	120-240	50 100 150 300 600 1 000	330 500 800 1 500 2 500 4 000	500 800 1 500 2 500 4 000 6 000	800 1 500 2 500 4 000 6 000 8 000	1 500 2 500 4 000 6 000 8 000 12 000

1) See annex B for application to existing different low-voltage mains and their nominal voltages.

2) Equipment with these rated impulse voltages can be used in installations in accordance with IEC 60364-4-443.

3) The / mark indicates a four-wire three-phase distribution system. The lower value is the voltage line-to-neutral, while the higher value is the voltage line-to-line. Where only one value is indicated, it refers to three-wire, three-phase systems and specifies the value line-to-line.

4) See 2.2.2.1.1 for an explanation of the overvoltage categories.

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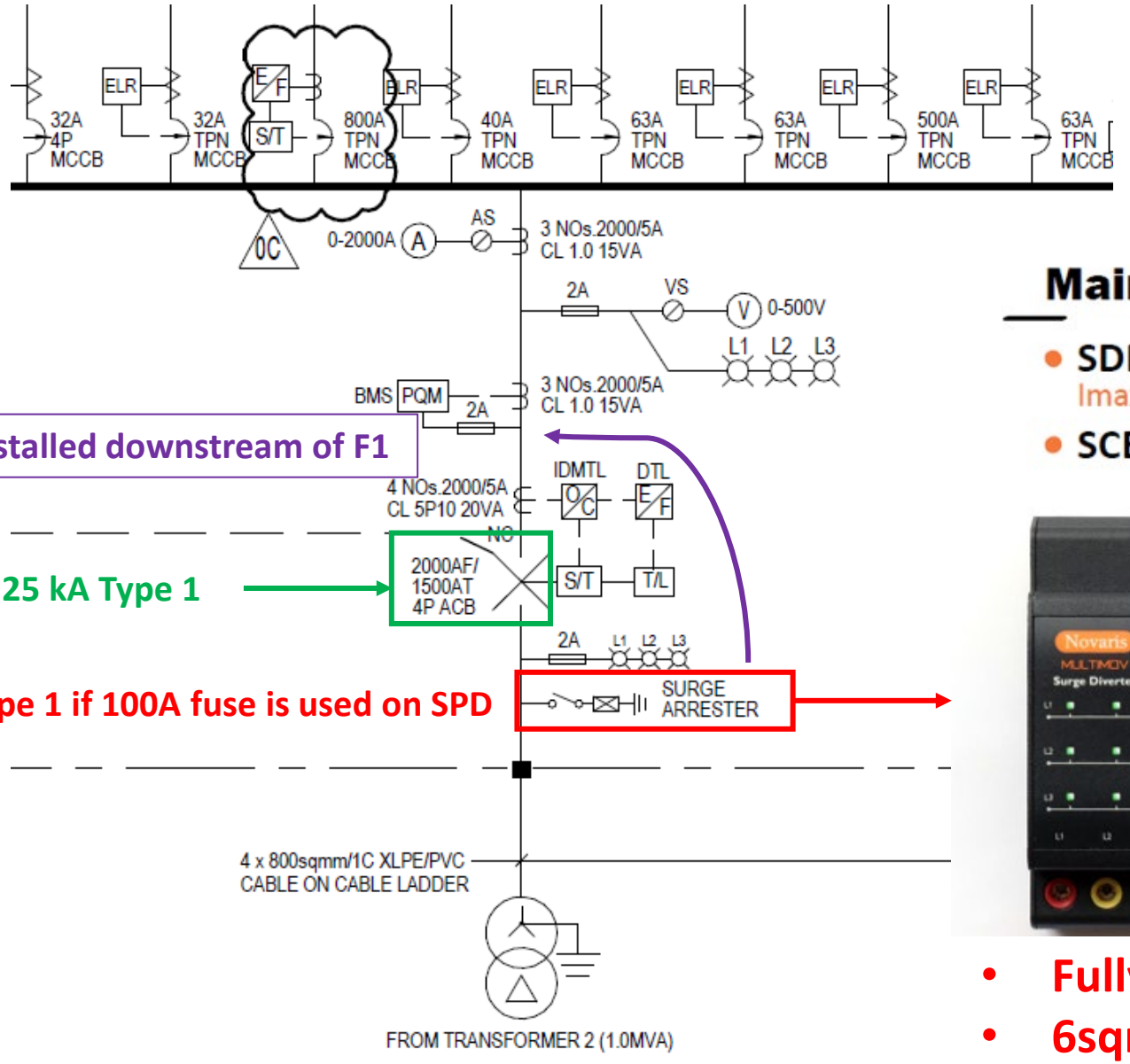

(F2 + SPD) should always be installed downstream of F1

F1: Can pass through 25 kA Type 1

F2: Only pass through 7.3kA Type 1 if 100A fuse is used on SPD

Main Switchboard

1

- SDN3-200-275
  Imax 200kA, Class 1+2
- SCB1-3-25 x3 nos

- Fully compliant to specs
- 6sqmm cables are enough

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Example of SPD Specification for Sub switchboard / DB

For Class II surge protection device at the electrical distribution system shall be able to withstand 40kA maximum discharge current Imax 8/20μs (per module). The voltage protection level Up at nominal discharge current In shall be less than or equal to 1.4kV. The Short Circuit withstand capability of the SPD must be equal to or greater than the short circuit rating of the switchboard at the point of installation. End of live disconnector (fuse or MCB) shall be installed with manufacturer recommendation.

125A HRC fuse + cables are required

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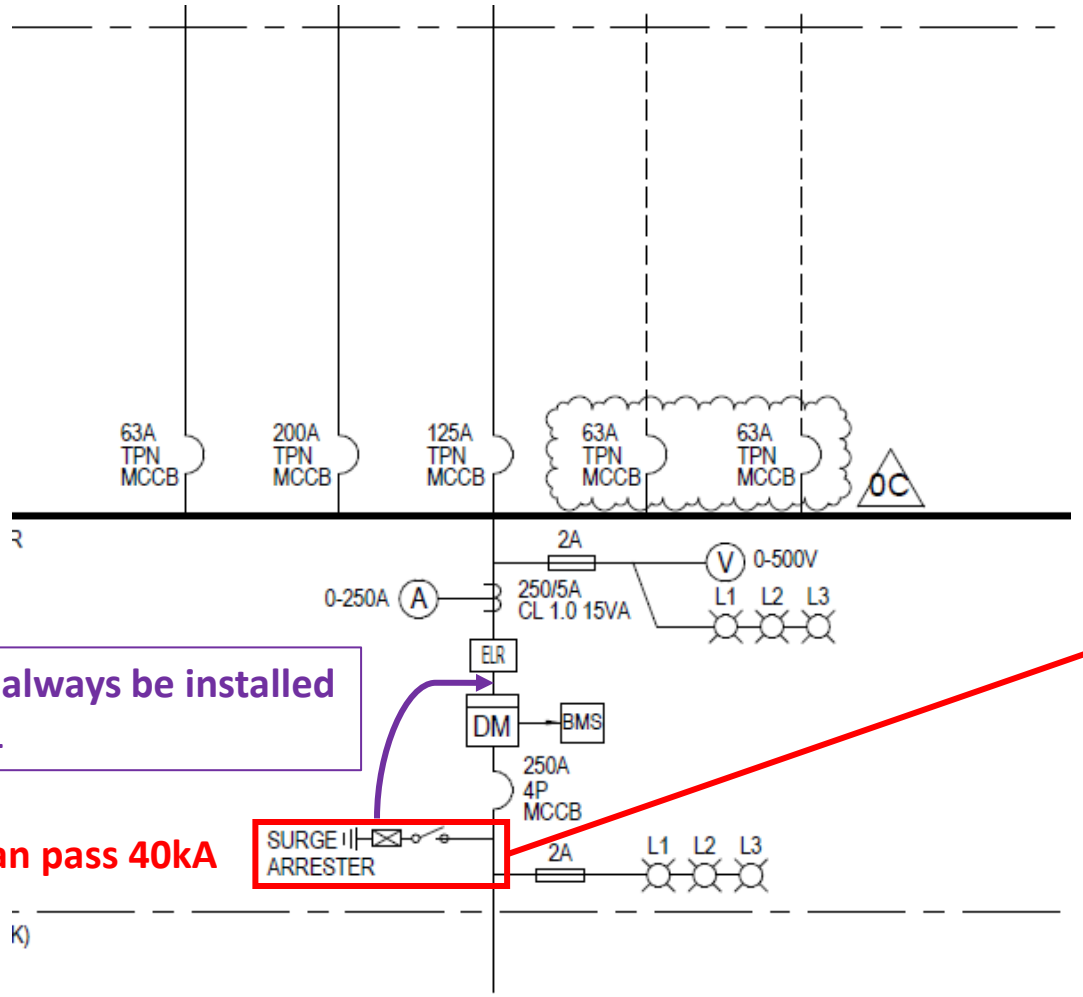

(F2 + SPD) should always be installed downstream of F1

F2: 125A MCB can pass 40kA

Sub Switchboard

2

- **SDD3-100-275**
  Imax 100kA, Class 1+2
- **SCB1-3-80** x3 nos

- **Fully compliant to specs**
- **4sqmm cables are enough**

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Installation Challenges & Cable Inductance

Cable Inductance

- V = I x R for cable is insignificant compared to
- V = L x di/dt for cable

- **16 sqmm cable**

  R = 5.3 mΩ/m,

  L = 1.05 μH/m

- For 10kA (8/20μs) surge:

  V_R = 53 V/m

  V_L = 1312 V/m

1m of cable can increase Up by 1300V!

Longer cable leads degrades SPD performance !

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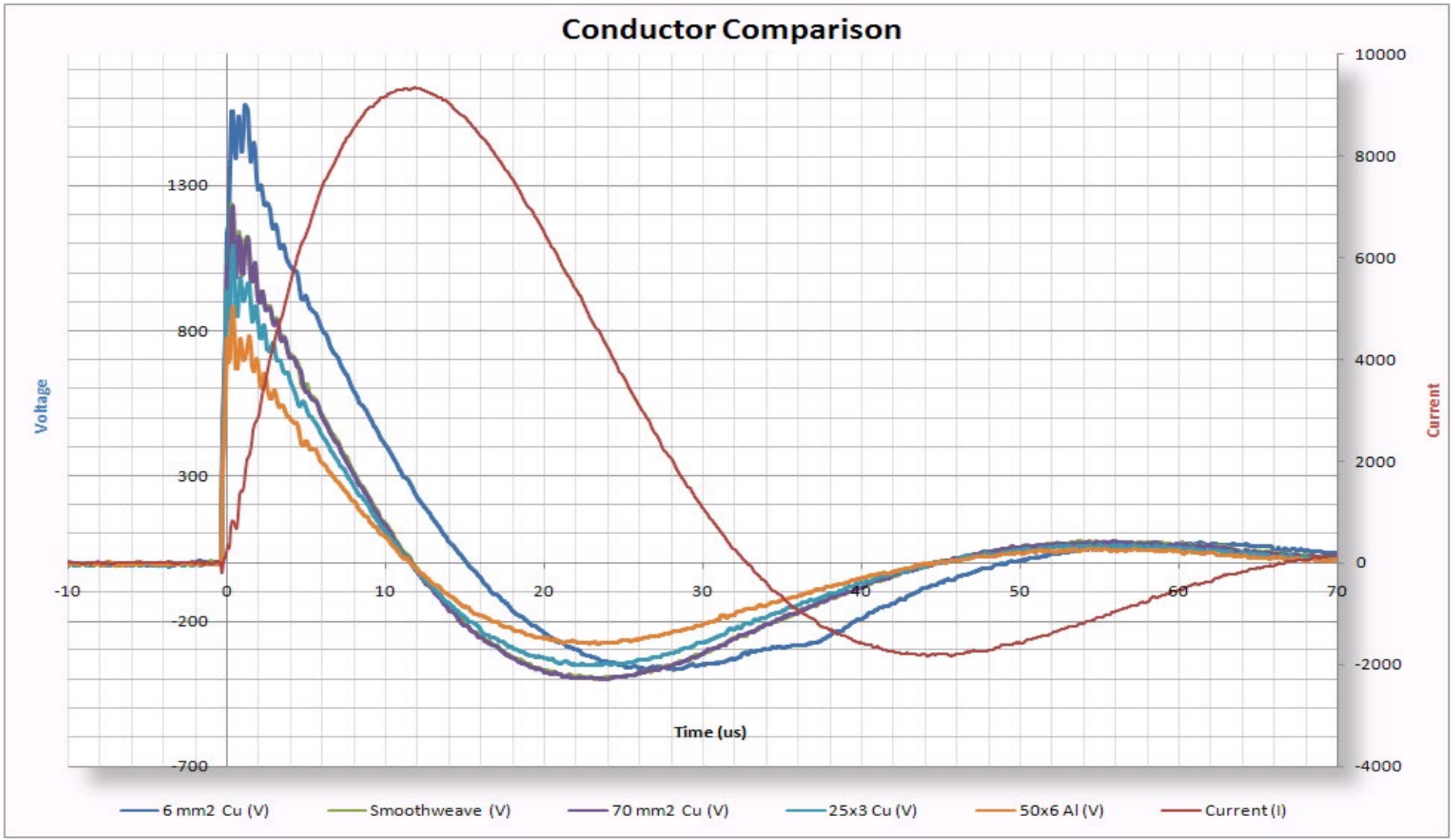
Importance of Inductance – 1m of different cable sizes comparison



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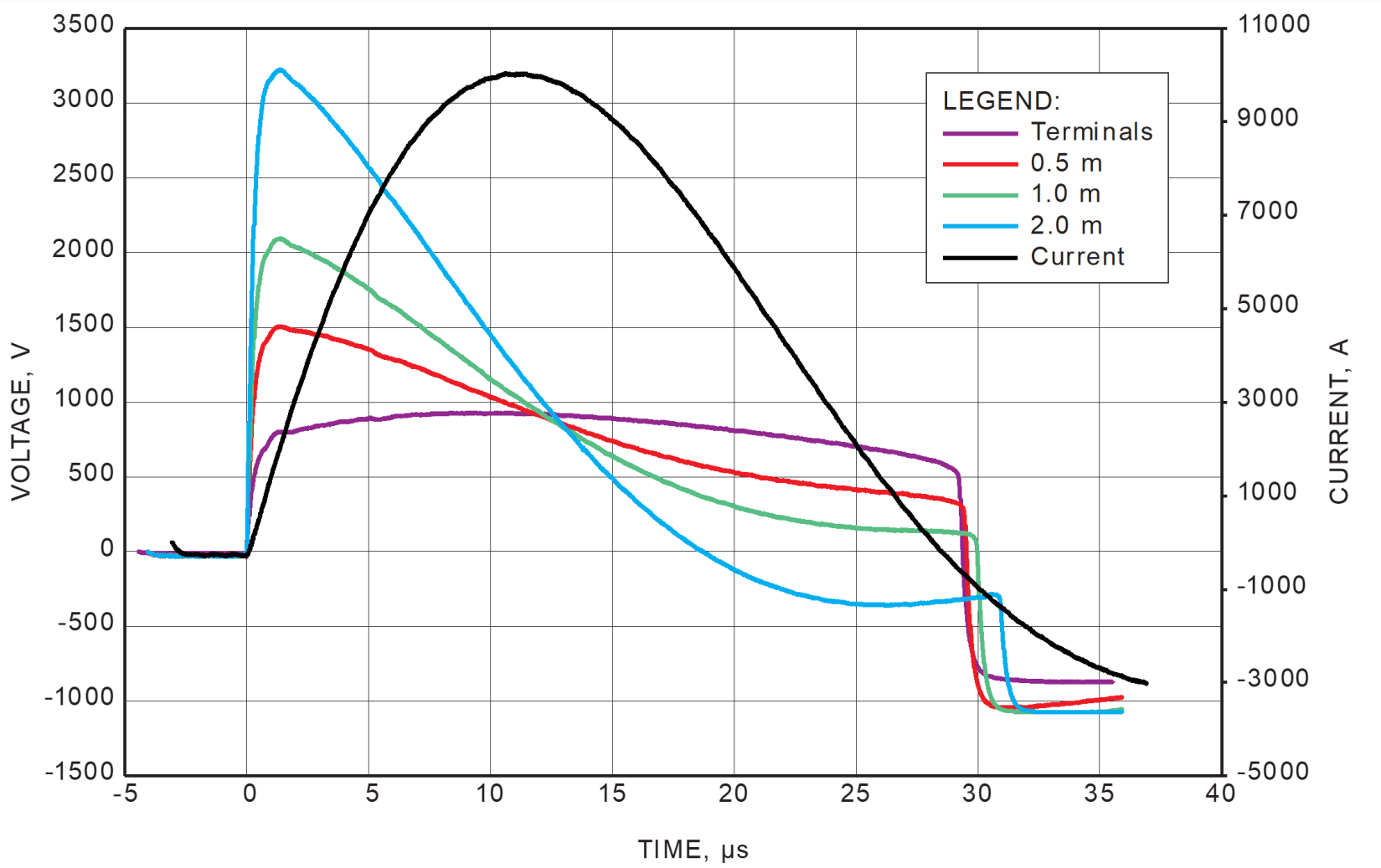
One Port SPDs – Effect of cable length on Up



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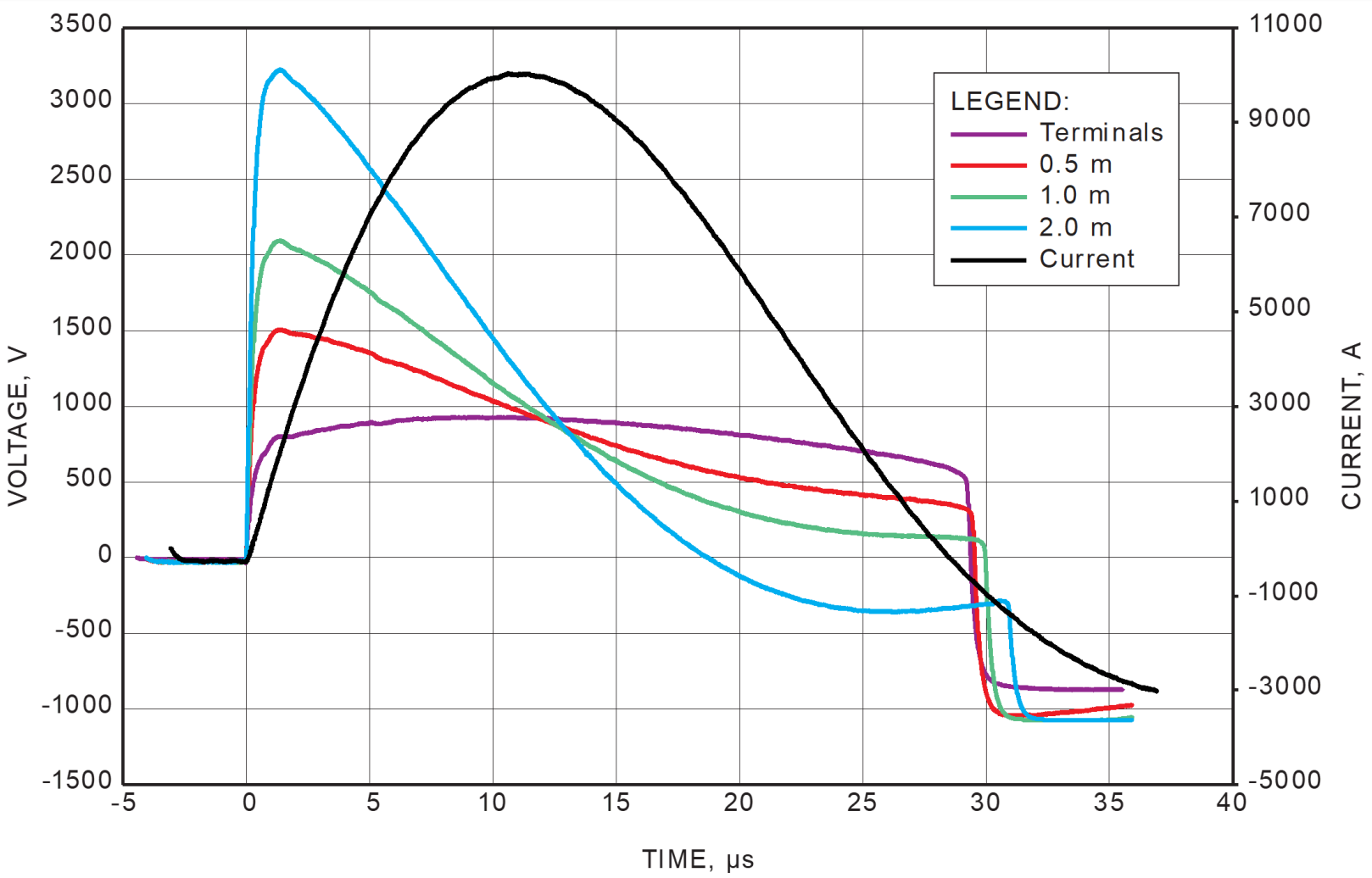
One Port SPDs – Effect of cable length on Up



- Test current (black) is 10kA 8/20µs.
- Line 1 (purple) shows the standard Up at approx. 800V.
- Line 2 (red) shows Up increase to **1500V with 0.5m cable**
- Line 3 (green) shows Up increase to **2000V with 1m cable**
- Line 4 (blue) shows Up increase to **3000V with a 2m cable.**

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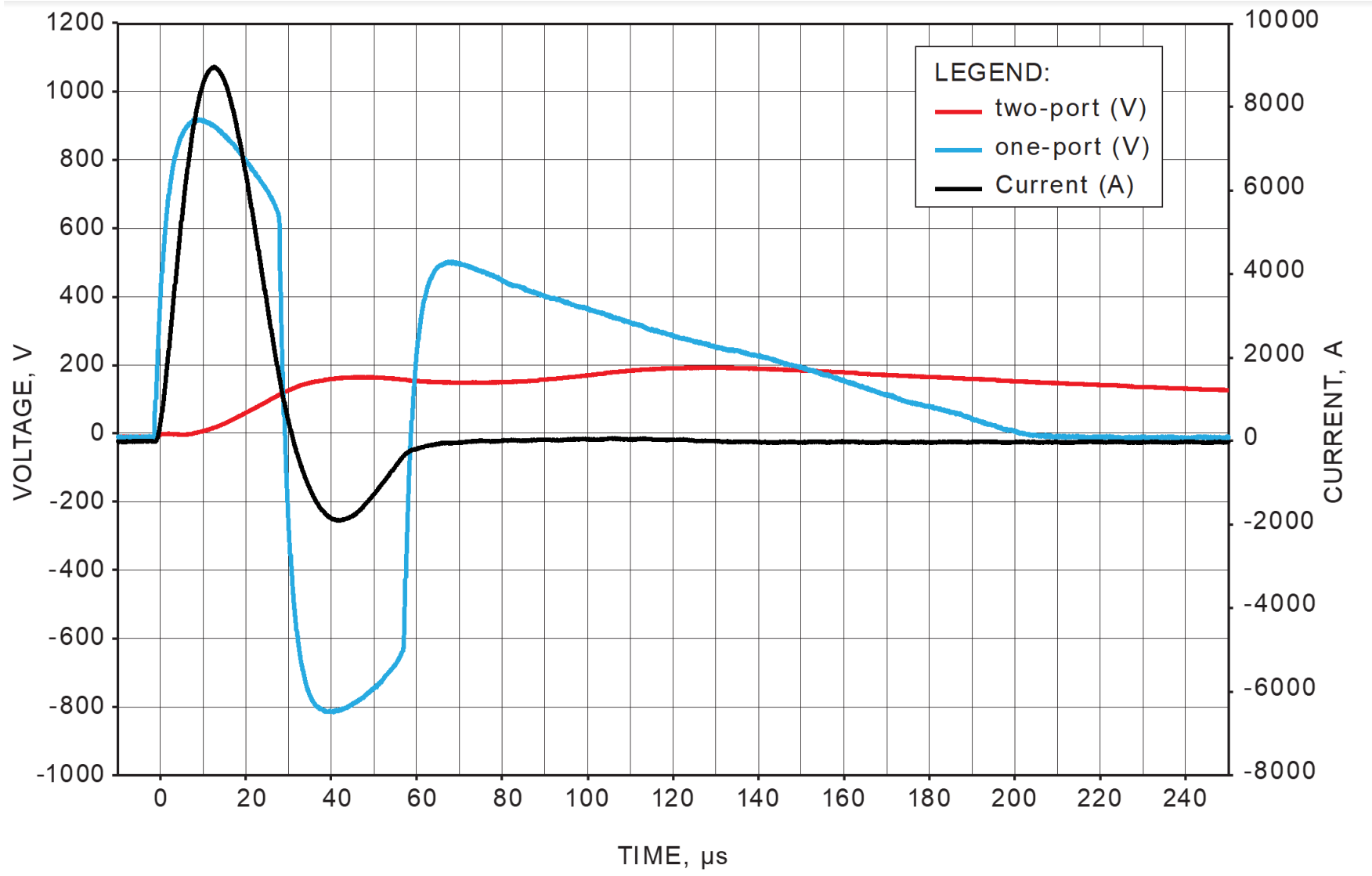
One Port SPDs vs. Two Port SPDs - Up



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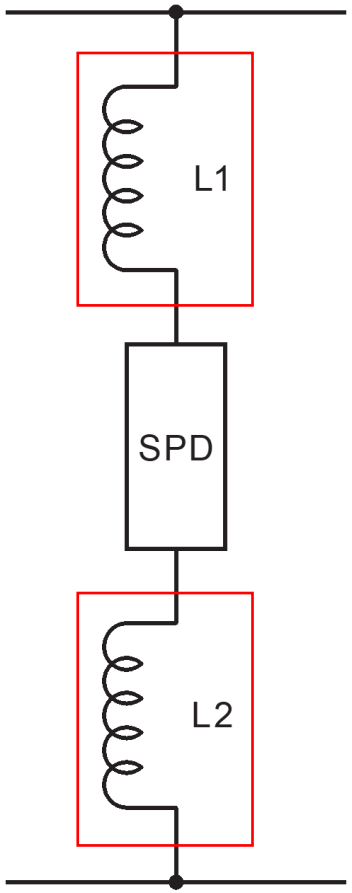
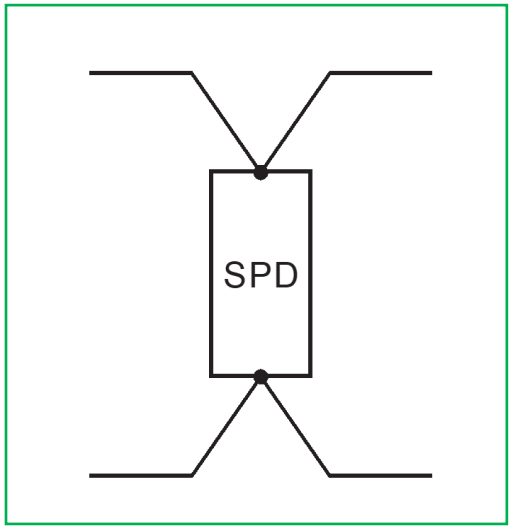
One Port SPDs Installation methods

Remember the effect of Inductance on Up

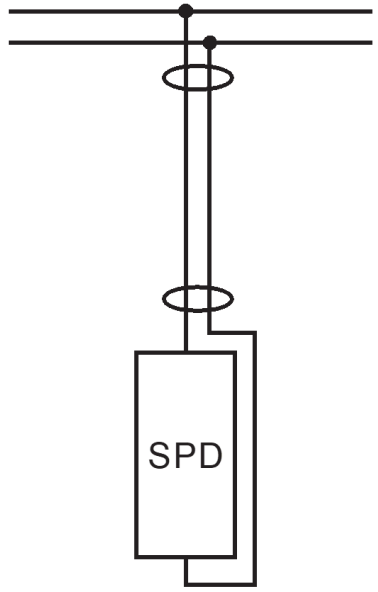
V = L x di/dt



(a) Poor



(b) Preferred



(c) Acceptable

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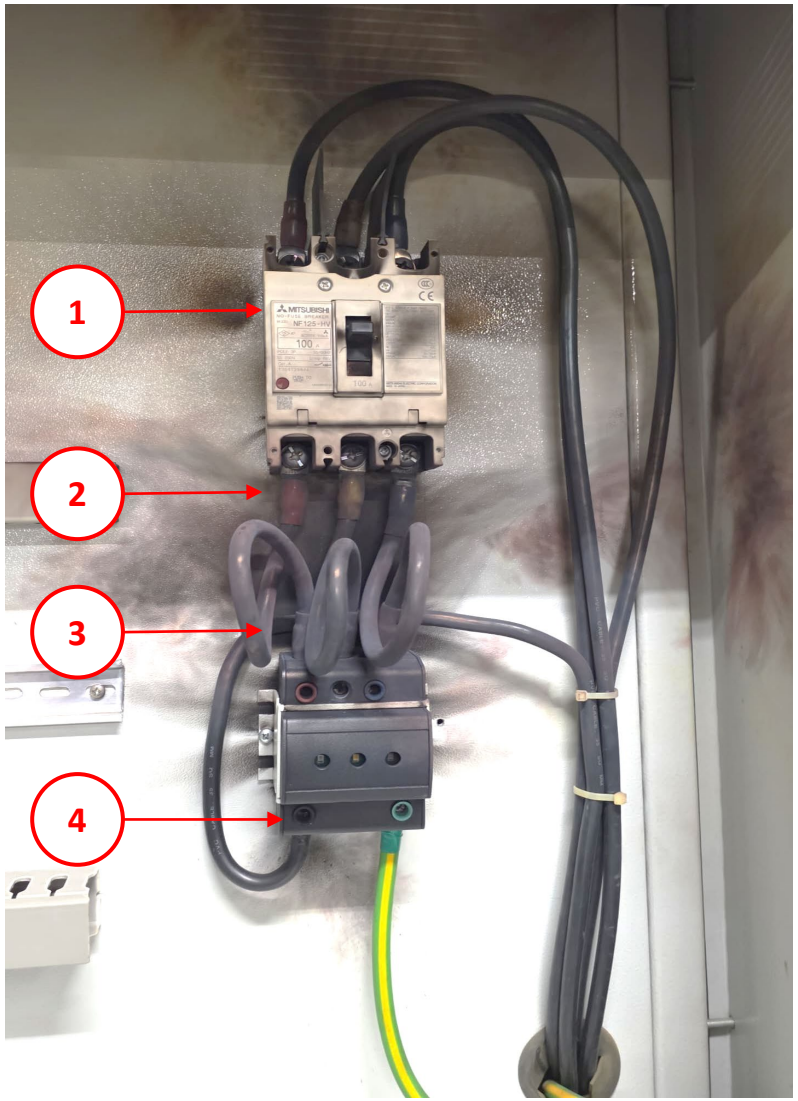
Cost-efficient Installation Practices

Case Study – Switchboard in Malaysia



Installation Mistakes:

1. **100A MCB** used for overcurrent protection
2. **Big cables** (>25 sq.mm) used not following SPD terminal capacity
3. **Cables coiled** (more Inductance)
4. **Grommets removed** to fit in big cables

Damages:

- x **MCB failed to trip**
- x **SPD MOVs burnt** and damaged
- x **Terminals damaged**
- x **Dangerous fire and explosion** in switchboard

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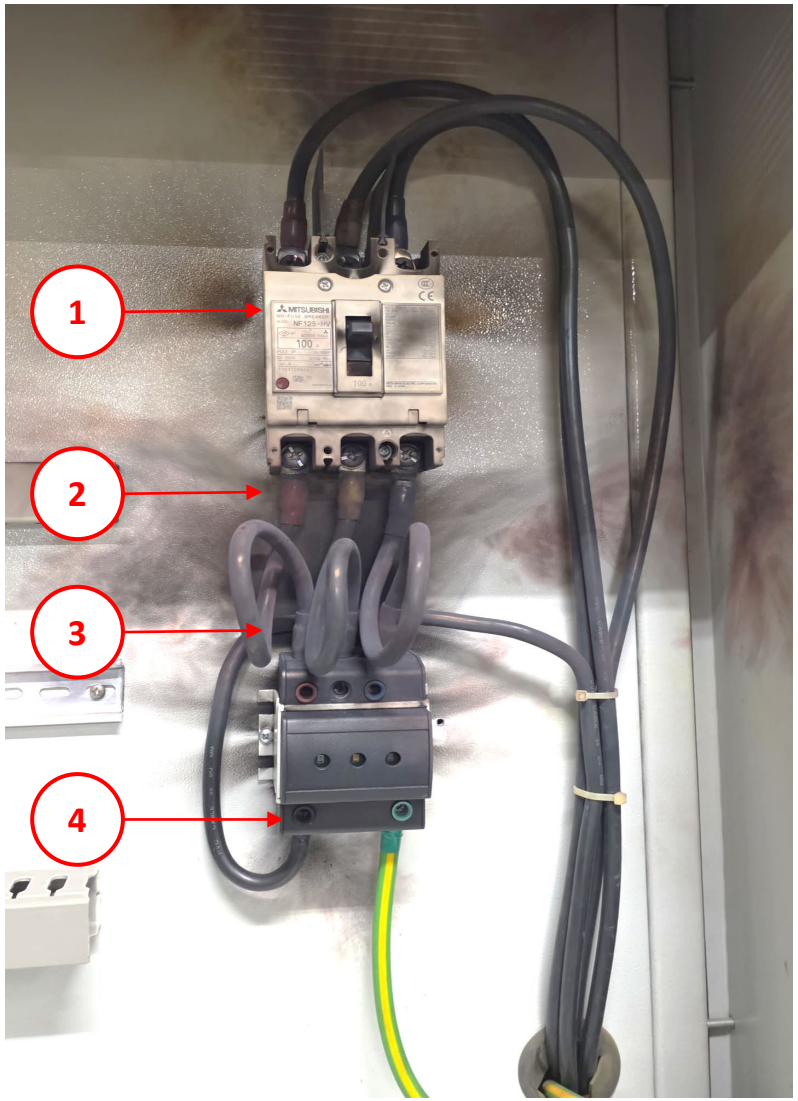
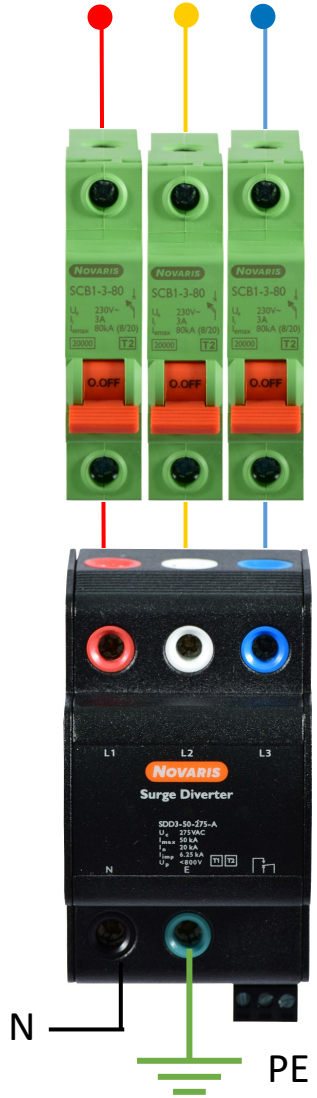
Case Study – Switchboard in Malaysia





Remedy:

- ✓ Use correct SCB with SPD
- ✓ Install short and smaller size cables
- ✓ Do not coil cables
- ✓ Connect Earth cable to the nearest earth stud on the panel
- ✓ Follow SPD installation guide

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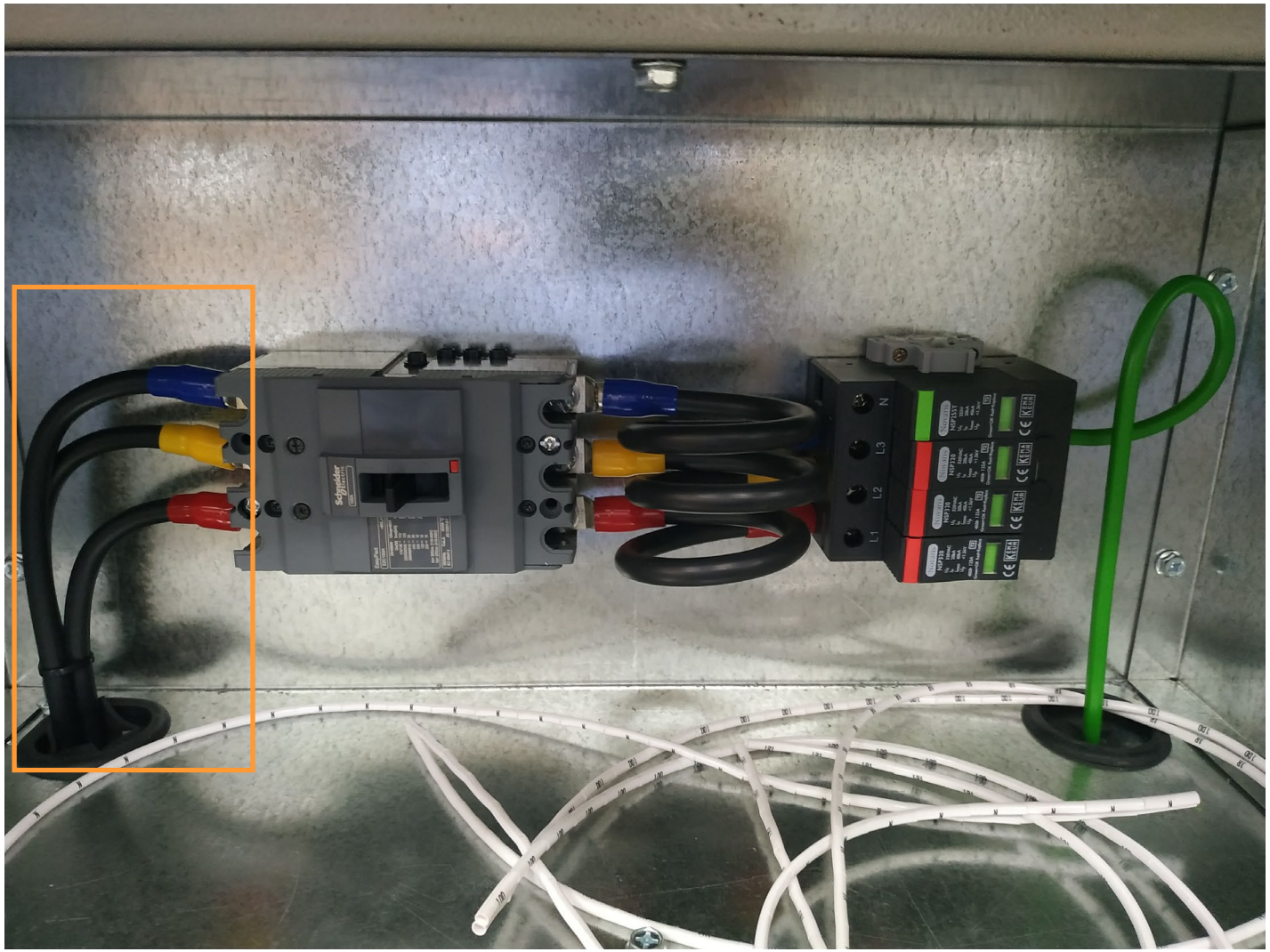
Common Installation Mistakes



Mistake #1 :

Cable is long due to SPD being far away from main incoming breaker.

Improvement:

SPD location to be as near to the main incoming breaker to minimize the total cable length.

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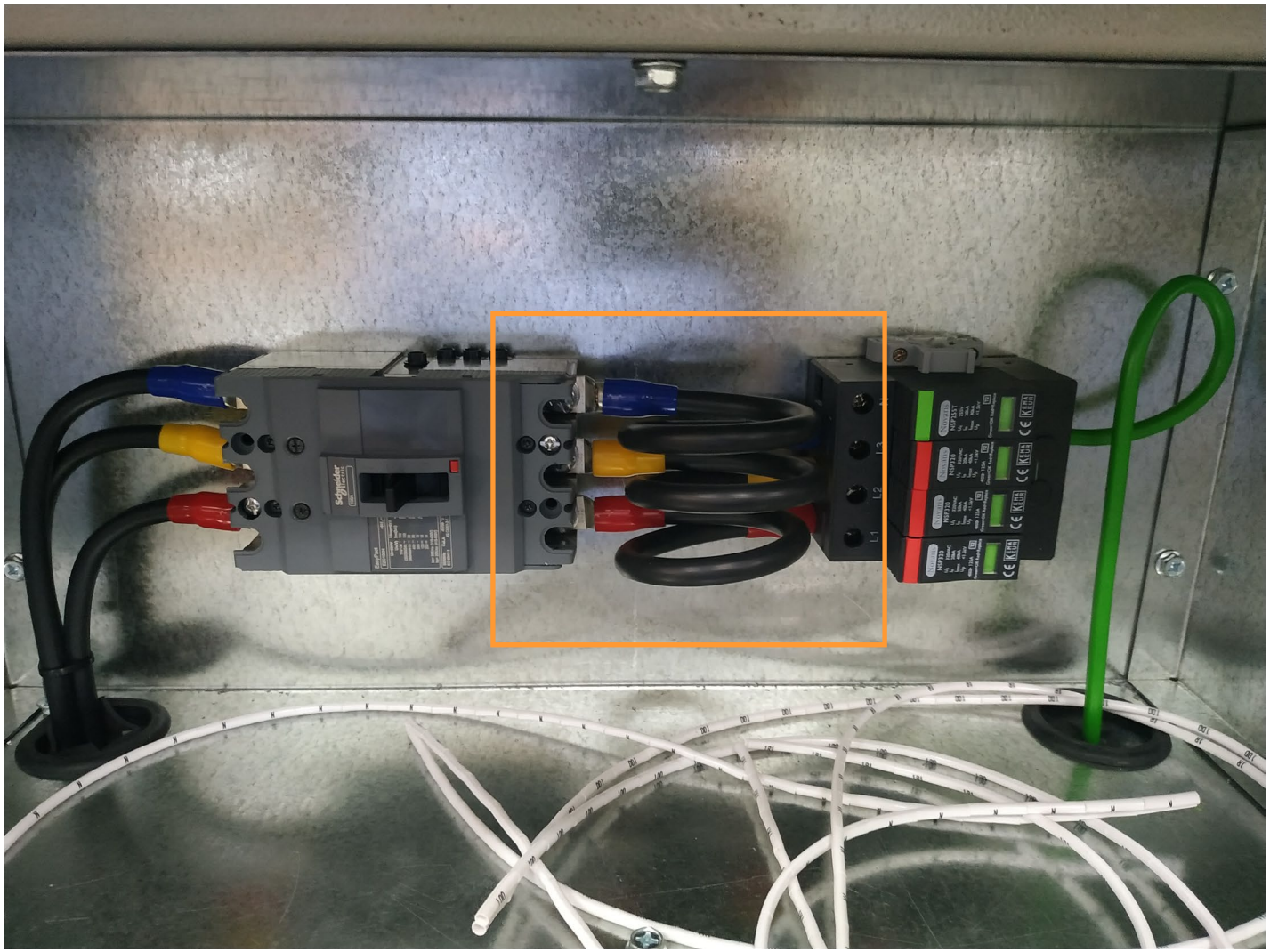
Common Installation Mistakes



Mistake #2 :

This cable **should not** be coiled. Coiled cable increases inductance

Improvement:

Maintain the cable straight into the SPD terminal

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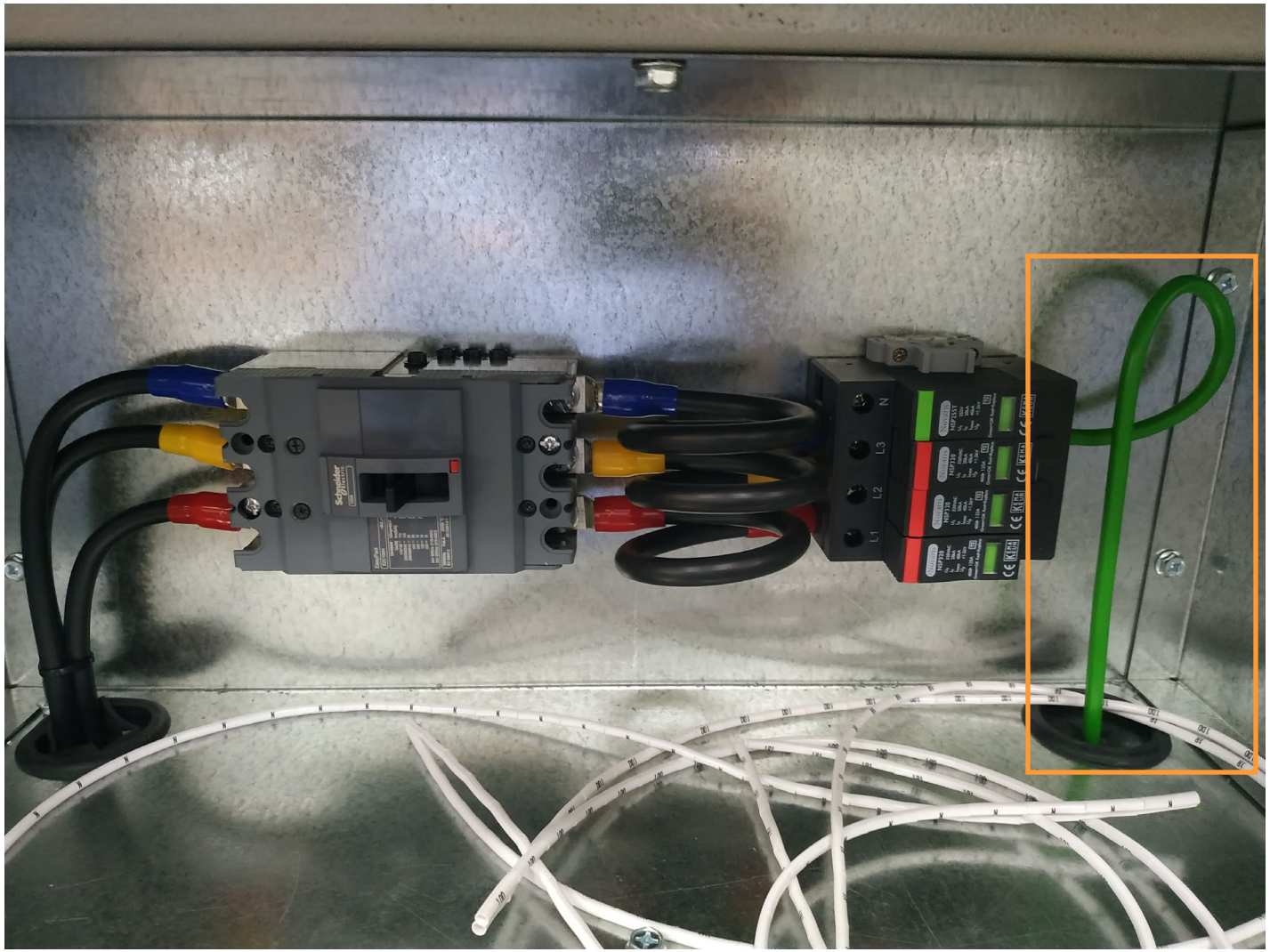
Common Installation Mistakes



Mistake #3 :

This cable should not be coiled.

Improvement:

Maintain the cable straight into the SPD terminal

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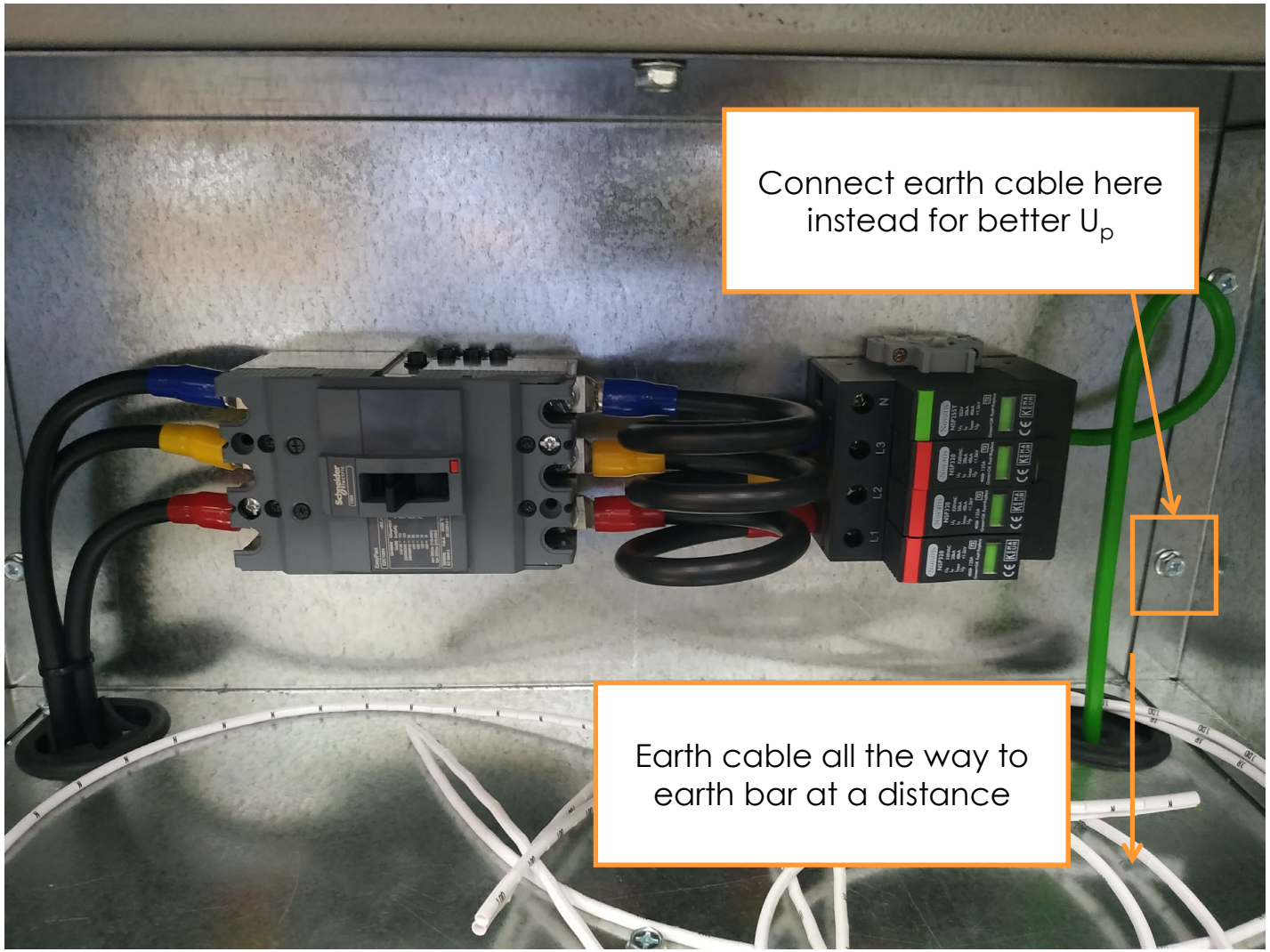
Common Installation Mistakes



Mistake #4 :

The earth cable is going is connected to the earth bar at the bottom of the panel. Cable length is significantly long.

Improvement:

Earth cable can be terminated to nearby stud as the body of the panel is already earthed.

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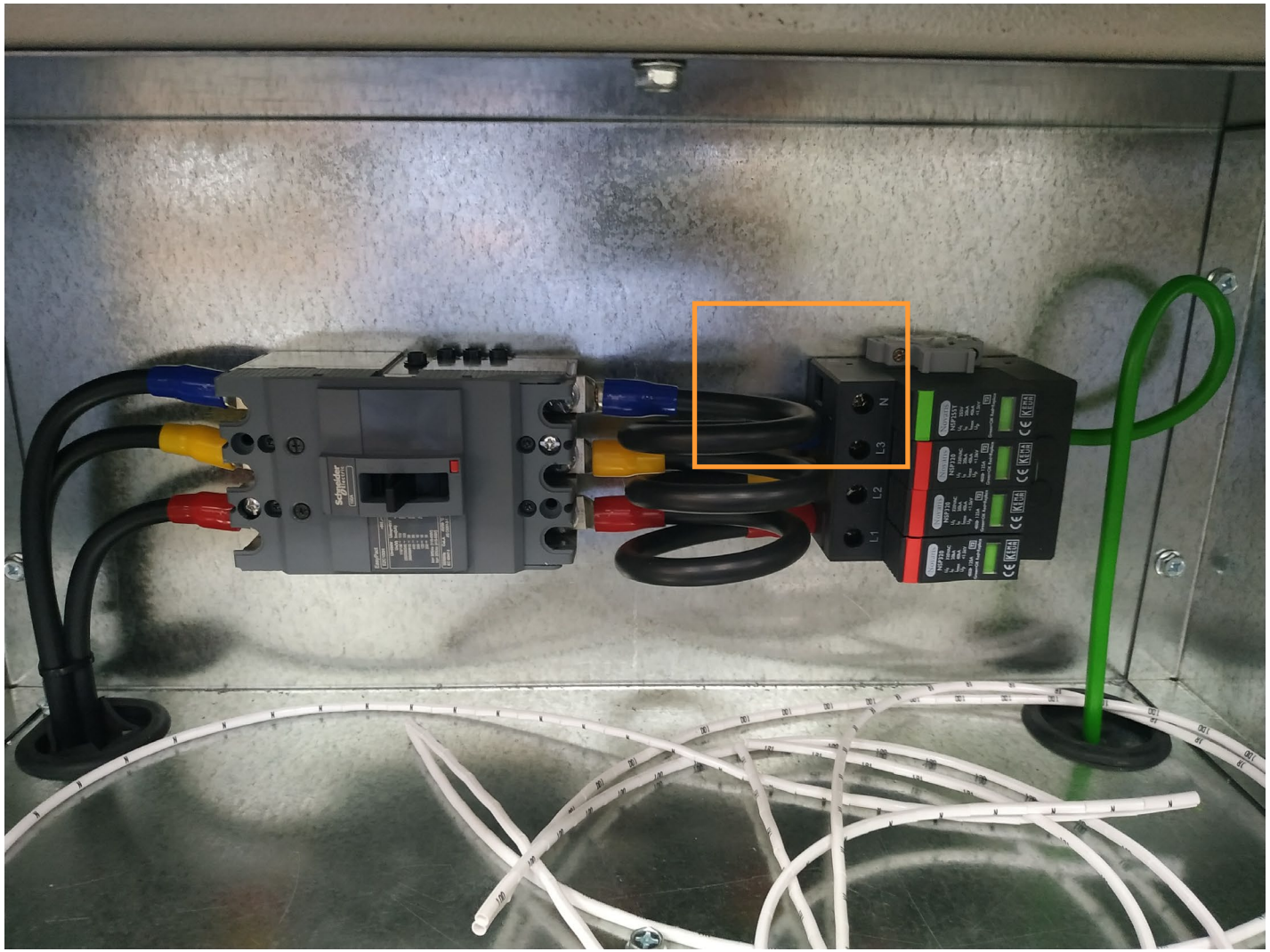
Common Installation Mistakes



Mistake #5 :

Neutral to be checked and thoroughly connected.

Improvement:

The use of neutral disconnector is unnecessary. This is to prevent unwanted broken neutral which can cause SPD to explode.

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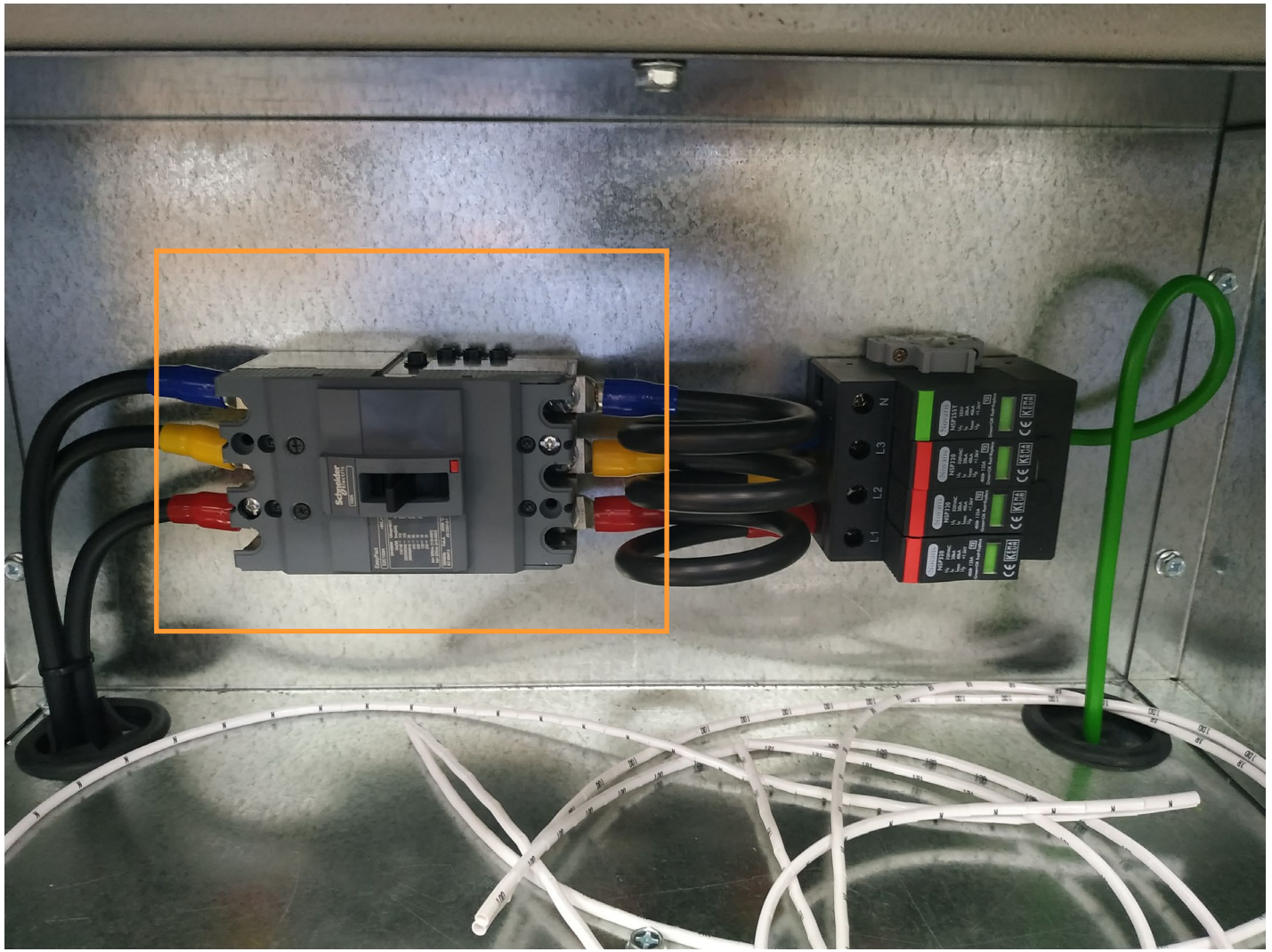
Common Installation Mistakes

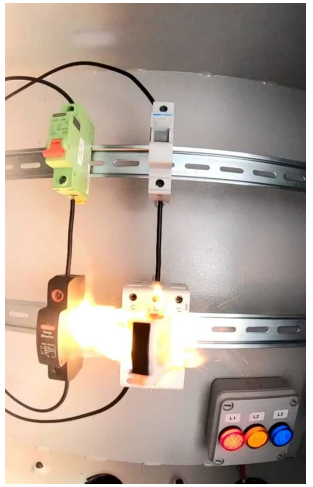


Mistake #6 :

Unsuitable overcurrent protection used for SPD purpose.

Improvement:

Use SCB



From INCOMING

L_1
L_2
L_3
N
E

MCCB/MCB

RCCB

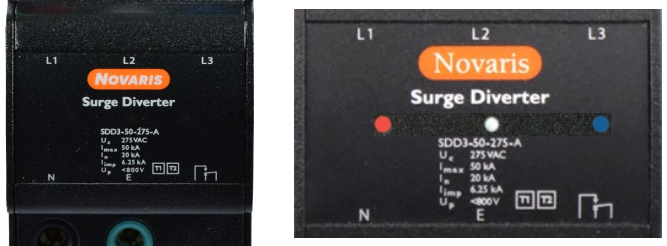
To Load / DB

X **RCCB is upstream of SPD**

X **MCB with SCB**

N

PE



SDD3-100-275
Surge Diverter

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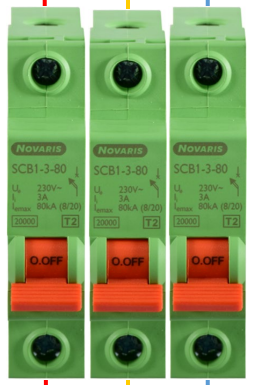
From INCOMING

L_1
L_2
L_3
N
E

MCCB/MCB

RCCB

→ To Load / DB



SCB1-3-80
Surge Circuit Breaker

- ✓ **RCCB should be downstream of SPD**
- ✓ **SCB with SPD**

SDD3-100-275-A
Surge Diverter

N

PE

Alarm contact

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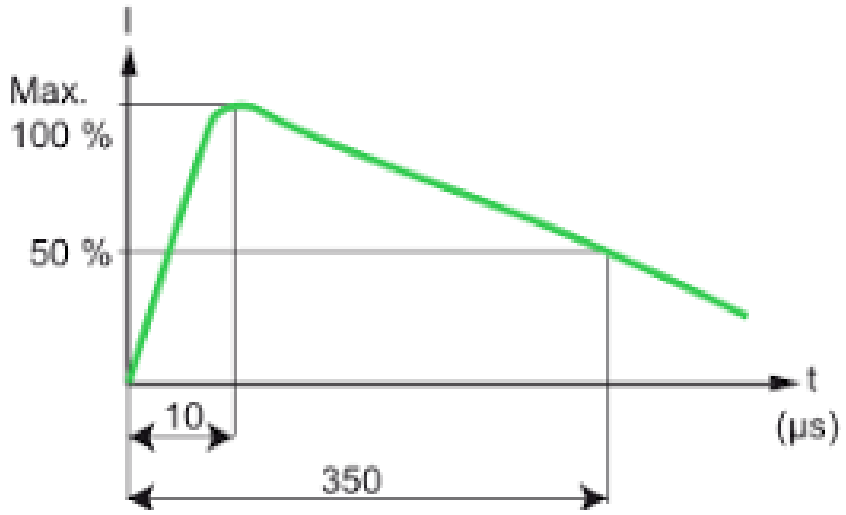
NOVARIS
Quiz Session

QUIZ SESSION

1. Identify the **Waveform**:



a) AC waveform

b) Class 1/Type 1 Impulse Waveform

c) Class 2/Type 2 Impulse Waveform

d) Amplitude modulation waveform

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QUIZ SESSION

2. Identify the **correct installation practices**: (Choose all applicable)

a) Cable length between SPD and equipment is short < 1m.

b) Separating SPD ground from equipment ground.

c) Coiled cables leading to SPD.

d) SPD is used along with SCB.

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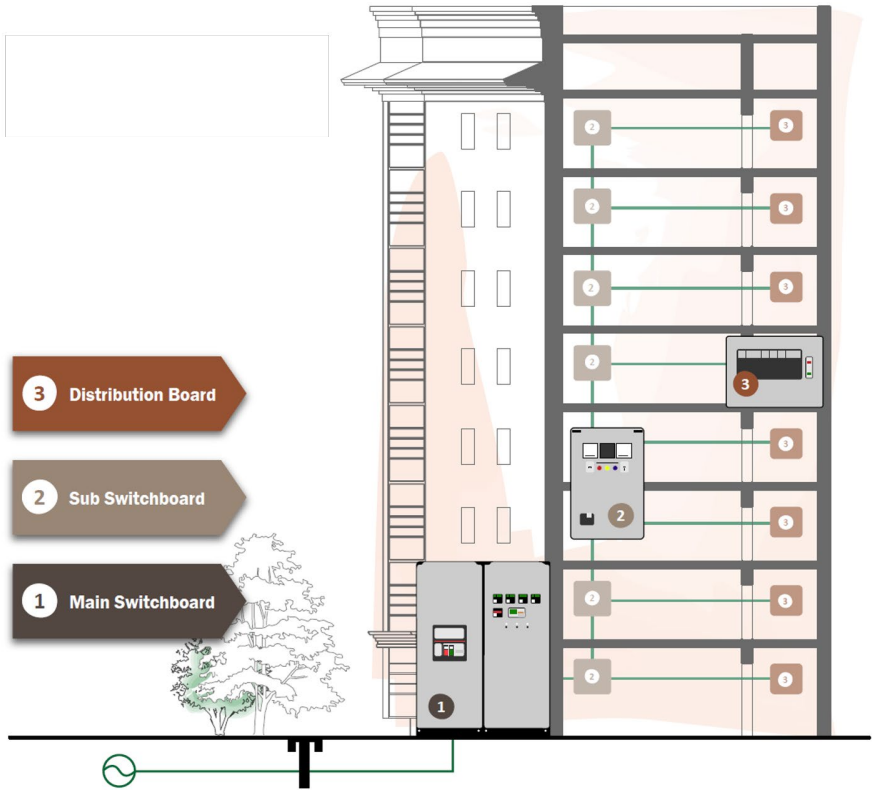
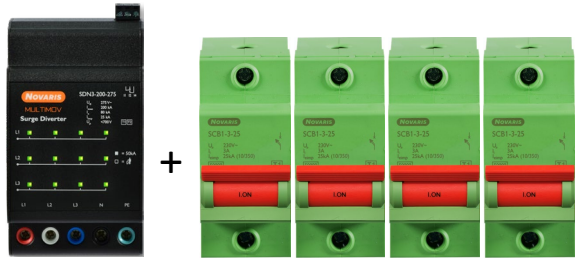
QUIZ SESSION

3. For a multi-storey commercial building with a 2500A switchboard, choose the right SCB combination for SDN3-200-275 with 25kA 10/350 rating.



1. Main Switchboard

A **SDN3-200-275 + 4 x SCB1-3-80**

B  **SDN3-200-275 + 4 x SCB1-3-25**

C **SDN3-200-275 + 3 x SCB1-3-25**

D **SDN3-200-275 + 3 x SCB1-3-80**

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QUIZ SESSION

4. **Which OCPD would be most suitable** for a 63A Single phase Distribution Board using a 40kA SPD?

a) SCB1-3-25

b) SCB1-3-80 ✓

c) 125A HRC fuse

d) 125A MCCB

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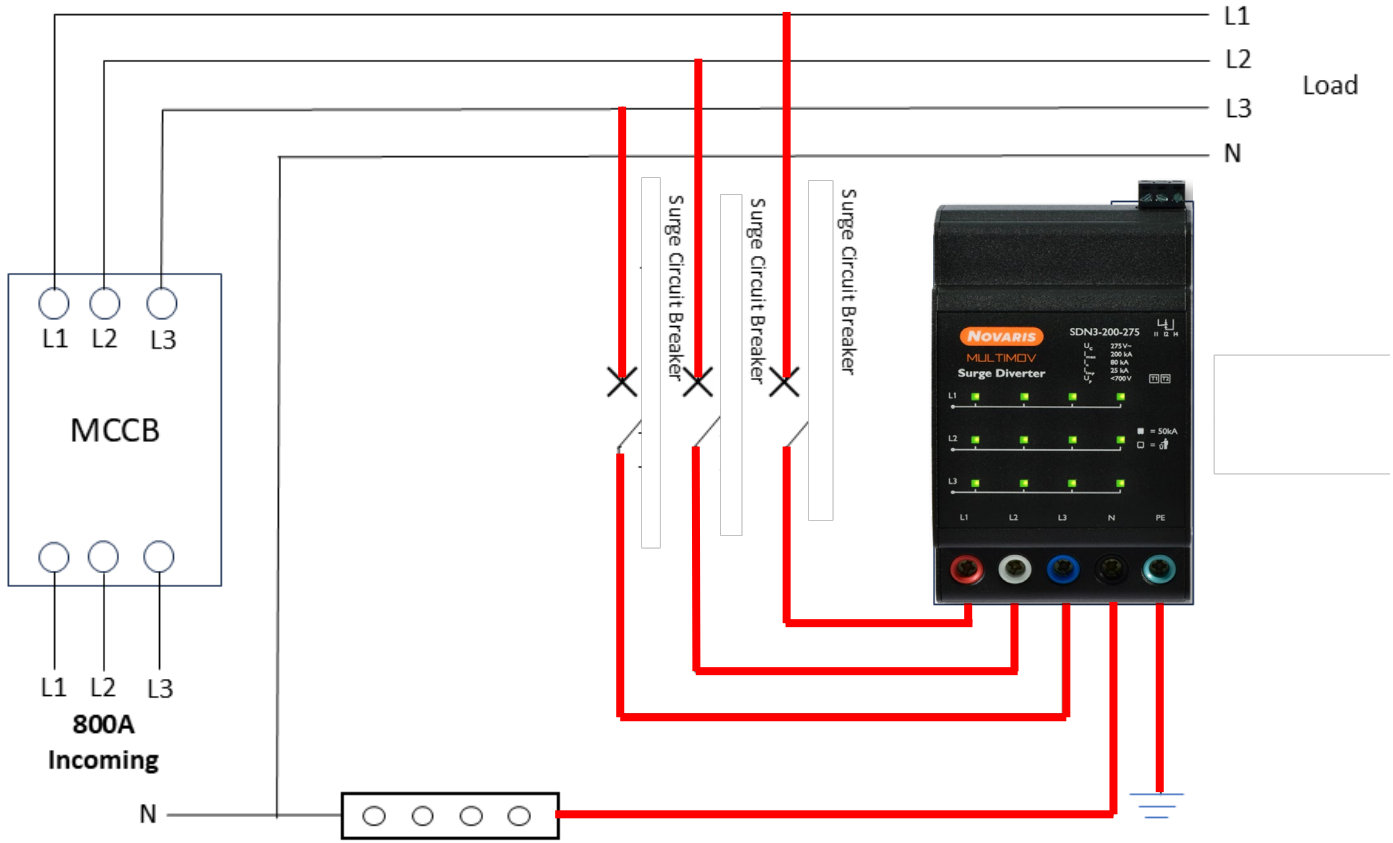
QUIZ SESSION

5. Which **SCB is best suited to coordinate with SDN3-200-275 (25kA 10/350)** and the best suited cable sizes (for all RED highlighted connections) to the SPD?



A. SCB1-3-25, 35mm² cables
B. SCB1-3-80, 6mm² cables
C. SCB1-3-25, 6mm² cables
D. SCB1-3-80, 25mm² cables

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QUIZ SESSION

6. Which are the **OCPDs that can allow a 12.5kA 10/350 surge** impulse to pass through?

a) 160A HRC fuse

b) 125A MCB

c) SCB1-3-25

d) 100A MCCB

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QUIZ SESSION

7. **Assume that a 2m length of a 16sqmm cable** is used to connect to an SPD with let-through voltage **(Up) of 800V**. **What will be the final let-through voltage** at the load after a surge?

a) < 800V

b) > 3000V

c) 230VAC

d) 100,000 V

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Let's Connect!

I'd love to connect and continue the conversation.

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- Based in Singapore
- Surge Protection Solutions for Industrial & Critical Infrastructure
- Let's connect and explore how we can work together.

Scan to connect

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Let's stay connected!

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